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THE HAWAIIAN PLANTERS' RECORD

Volume XXV. JULY, 1921 Number 1

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Moreton Bay Fig Wasps in Hawaii.

Mr. Osborn gathered some figs from the Moreton Bay fig tree in Emma Square on June 22nd, and found that they contained fig wasps (*Pleistodonta froggatti*). Ten days later a large crop of ripe fruit fell from this tree, which was appreciated by the Mynah birds and small boys. Since then the wasp has been found to be established on the Moreton Bay fig up Nuuanu.

The wasp was received from Mr. Pemberton on February 9th, and liberated on the 9th and 10th of February. It is evidently the second, or even the third, generation in Honolulu. We can therefore consider that it is established and, unless something unforeseen happens, will continue to thrive and fertilize the Moreton Bay figs.

The difference between the ripe and unfertilized figs is very evident on account of their size, shape, and color. The caretaker at Emma Square noticed the difference, and stated that the ripe figs were being gathered to make pies of. It is feared they would make very seedy pies.

This is the first case on record where the fig wasp of a wild fig tree has been established outside of its natural habitat, and demonstrates the necessity of the presence of the wasp for the production of seeds in the fig.

There is an important point still not settled in the relationship of the wasp to the fig. Is it simply the pollenization that causes the young fig not to fall and to continue to develop, or is it some stimulus caused by the presence of the wasp or the action of egg laying? Now that we have fertile pollen we may be able to settle the question.

F. M.

Selection of Superior Strains in Plant Improvement.

Additional evidence that agricultural crops can be improved through finding, isolating, and propagating superior individual plants is offered by articles bearing on the improvement of yields of potatoes and rubber, reprinted in this issue from other journals.

The selection methods seek specimens or strains that are definitely better than the average run, and that have, furthermore, the prepotency to transmit to their progeny this inherent superiority.

The Fern Weevil in Australia.

F. MUIR.

A consignment of the fern weevil parasite, a species of *Ischiogonus,* arrived by the S.S. Makura on May 21, and several adults came through in good condition. Some of them have been liberated on Tantalus and others kept for breeding in captivity. It will take several months before we shall have any knowledge of their establishment in the Territory.

The following extract from a letter from Mr. Pemberton, dated Lismore, Richmond River, New South Wales, April 30, 1921, gives some interesting details of the condition of the fern weevil and its parasites in its natural habitat.

"I have spent the past twelve days on the Richmond River in northern New South Wales, searching in the forests at the source of some of its tributaries for the fern weevil *Syagrius fulvitarsis.* I have found the weevil, have bred a parasite from its larva, and am now bound for Sydney with about fifty individuals of the parasite in the egg, larval and pupal stages. I will place these on the S.S. Makura, in charge of the captain, and will put some in the cool chamber or vegetable room. It will be many days before they reach Honolulu, but the chance of some surviving must be taken. Perhaps some of the adults will not be ready to emerge before reaching Honolulu.

"When I reached Lismore, on the Richmond River, I found no forests or uncut scrub left, but some twenty miles up its tributaries I came to magnificent, virgin forests, containing an abundance of ferns. I soon found the weevil, though it is comparatively rare. I found it in dense, untouched forests, deep in their interior. I am convinced that it is native here and not introduced, though all previous collections of it seem to have been in greenhouses in Australia. French, the original collector, took it at Wien Wien (spelled Whian Whian now). I visited Whian Whian. It is now a smooth, rolling cattle country, but was all dense forest in 1857 when French was there. So French must have taken it in the forest.

"I have found the weevil in widely separated forest areas. It is thus well distributed, but scarce, as above observed. It is well under control. Ferns look well everywhere. In some spots I found the weevil more numerous than in others, but nowhere doing damage. The forests where I found it are all very wet. They were dripping with water, and mists and rain kept everything wet during my visit. Yet the parasite does its work and is apparently the main factor operating against the weevil. I also found it in widely separated localities. As the weevil is uncommon I have been unable to secure but a very small quantity of the parasite. On some days, in rich fern growth, I would find only three or four *Syagrius* larvae and as many adults.

"During the entire period I found perhaps two hundred *Syagrius* eggs. All were saved and carefully examined. I have a compound microscope with me. Yet I found no indications of egg-parasitism, and I have found but the one species of larval parasite. The parasitism of the larvae I did find was low.

About 10 per cent were parasitized. Such is often the case when an insect is well under control by its natural enemies. A rapid increase in the weevil can easily bring up the per cent of parasitism. A parasite and its host will frequently go through increases and decreases, first in favor of one and then the other. I think it quite likely that such is the case with the weevil and its parasite here. I found a fair abundance of empty cocoons of the parasite in the old, dead fern stems, indicating a recent high parasitism.

"The parasite is of the Ichneumon type. In one of the packages, containing living material, I include a vial containing three adult parasites. Mr. Timberlake can no doubt determine the sub-family and genus. I would be glad to know what his determination is.

"The female parasite deposits a single, minute, elongate egg on the surface of a well-developed larva. She forces the ovipositor through the fern stem, from the outside, and stings and partially paralyzes the larva. More than one egg is usually placed on the larva, but they are deposited singly. From one to five eggs are usually laid. The egg hatches into a minute, delicate larva, which moves slowly about over the surface of the weevil-larva, feeding externally upon it and ultimately extracting most of its body-fluid and leaving only the hard head and a little tissue The parasite-larva then spins a white cocoon over or near the remains of the weevil-larva and pupates therein and finally emerges as a mature wasp and gnaws its way out of the fern stem. Mating occurs immediately after mergence. I have not further elaborated on the life history of the parasite, having as yet had but a few days for such observations."

Plant Food Requirements.

Hawaiian Commercial & Sugar Company Experiment No. 7, 1921 Crop.

This was an experiment planned to determine the values of phosphoric acid and potash, when used in different combinations and amounts.

The cane was H 109, planted in June, 1919, and not cut back. The field was harvested in April, 1921.

All the phosphoric acid and potash used in this experiment were applied in

All phosphoric acid and potash used in this experiment were applied in one one dose in September, 1919, while the nitrogen was applied in four doses, in September, November, January, and April.

The amounts of each ingredient used are given in tabular form as follows:

Plots	No. of Plots	Pounds per Acre						
		Sept. 1919	Nov. 1919	Jan. 1920	April 1920	Nitrogen	P_2O_5	K_2O
C	14	286 lbs. N. M........	286 lbs. N. M.	286 lbs. N. M.	323 lbs N. S.	200	0	0
L	13	286 lbs. N. M........ 625 lbs. Acid phos....	" "	" "	" "	200	100	0
M	13	286 lbs. N. M........ 1250 lbs. Acid phos..	" "	" "	" "	200	200	0
N	13	286 lbs. N. M....... 625 lbs. Acid phos.... 200 lbs. Sulp. potash.	" "	" "	" "	200	100	100
O	13	286 lbs. N. M........ 400 lbs. Sulp. potash.	" "	" "	" "	200	0	200

The results obtained from the harvesting of this experiment were as follows:

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Nitrogen only	48.2	6.80	7.09
Nitrogen and phos. acid (100 lbs. P_2O_5)	50.0	6.80	7.35
" " " " (200 lbs. P_2O_5)	49.0	6.79	7.22
Nitrogen, phos. acid and potash.......	48.1	6.76	7.12
Nitrogen and potash................	47.0	6.79	7.08

A chemical analysis of the soil made at the time that the experiment was laid out showed this soil to be high in both phosphoric acid and potash. It was especially high in potash. The total citrate soluble phosphoric acid was 0.021% and the total acid soluble potash was 0.77%. The soils at Waipio have not responded to either phosphoric acid or potash and contain considerably less of those two elements than that given above.

The results at Puunene show some response to phosphoric acid but none whatever to potash. The plots getting nitrogen and phosphoric acid (L and M plots) produced about 0.2 tons of sugar more per acre than did the plots getting nitrogen and potash or nitrogen alone.

The need of phosphoric acid is not very great and is fully supplied by the phosphoric acid in the mixed fertilizer now being used on that plantation.

DETAILS OF EXPERIMENT.

Fertilization — Plant Food Requirements.

Object:

To determine the plant food requirements of sugar cane under conditions at Hawaiian Commercial & Sugar Company.

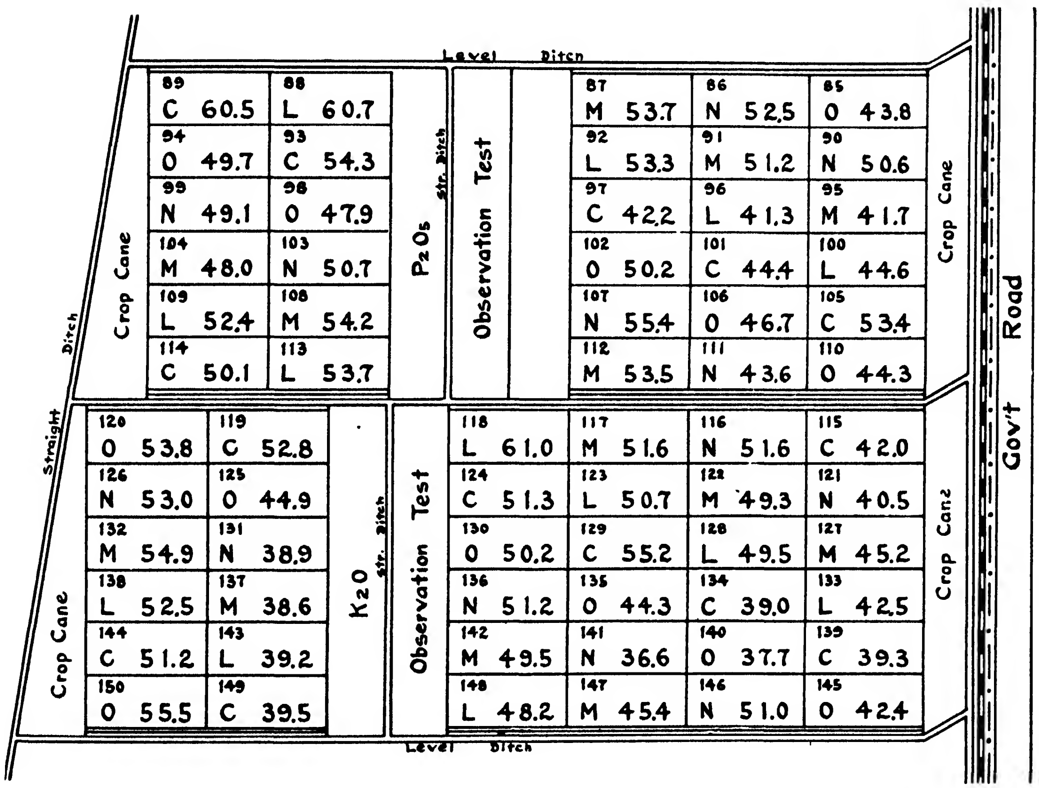
Location:

Field B.

Crop:

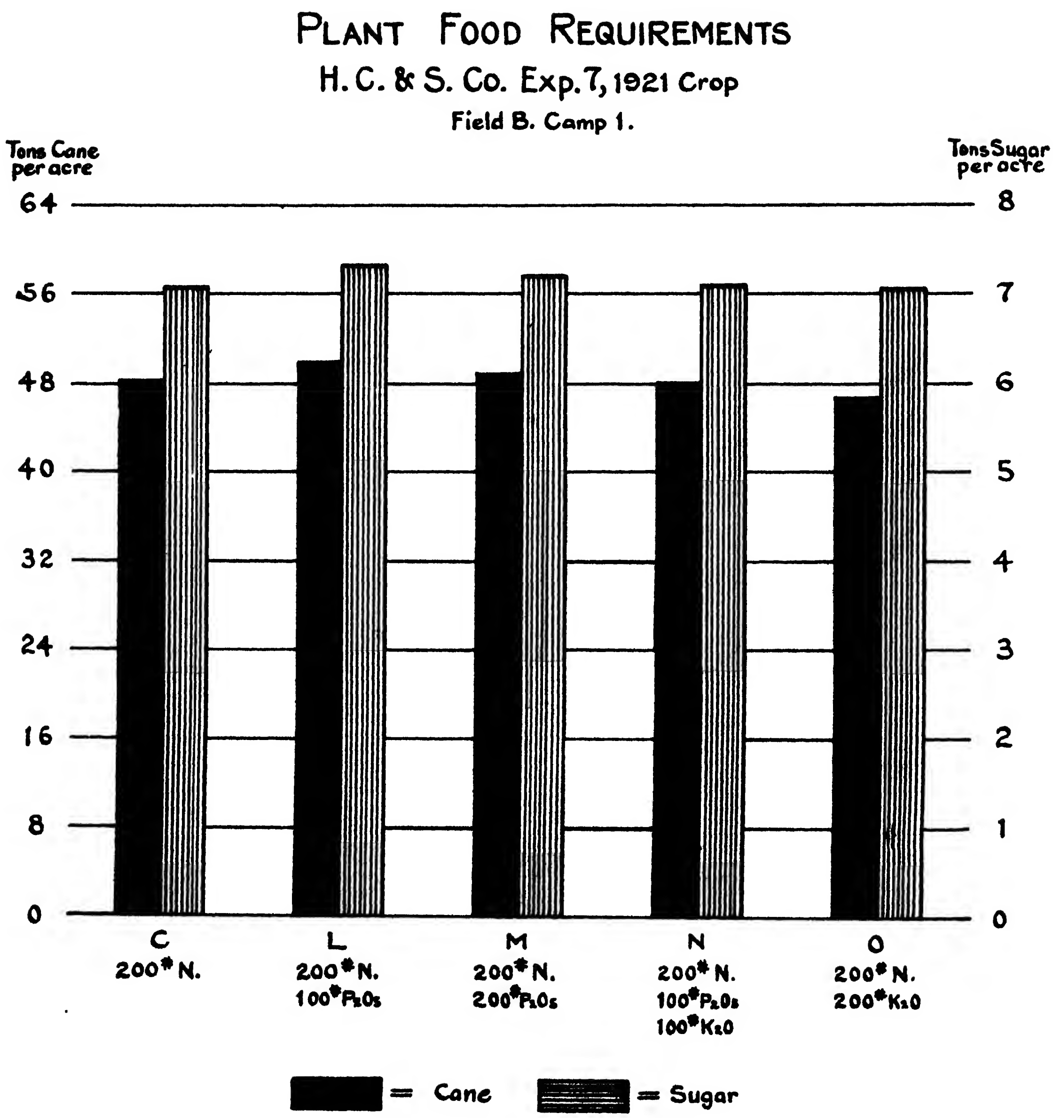
H 109, plant.

PLANT FOOD REQUIREMENTS
H. C. & S. Co. Exp. 7, 1921 Crop
Field B. Camp 1.



Summary of Results

Plots	No. of Plots	Treatment			Yieds Per Acre		
		Nitrogen	P_2O_5	K_2O	Cane	Q. R.	Sugar
C	14	200*	0	0	48.2	6.80	7.09
L	13	200*	100*	0	50.0	6.80	7.35
M	13	200*	200*	0	49.0	6.79	7.22
N	13	200*	100*	100*	48.1	6.76	7.12
O	13	200*	0	200*	47.0	6.79	7.08


PLANT FOOD REQUIREMENTS
H. C. & S. Co. Exp. 7, 1921 Crop
Field B. Camp 1.
Tons Cane per acre
Tons Sugar per acre
64
56
48
40
32
24
16
8
0
8
7
6
5
4
3
2
1
0
C
200# N.
L
200# N.
100# P2O5
M
200# N.
200# P2O5
N
200# N.
100# P2O5
100# K2O
O
200# N.
200# K2O
= Cane
= Sugar

Layout:

No. of plots = 66.

Size of plots = 1/20 acre; each plot is 6 lines by 2 water-courses, each line being 5′ wide by 72.6′ long.

Plan:

Plot	No. of Plots	Septembr 1, 1919			Nov. 1, 1919	Feb. 15, 1920	April 15, 1920	Total N	Lbs. P. A. P_2O_5	K_2O
		N	P_2O_5	K_2O	N	N				
C	14	50	...	...	50	50	50	200	...	...
L	13	50	100	...	50	50	50	200	100	...
M	13	50	200	...	50	50	50	200	200	...
N	13	50	100	100	50	50	50	200	100	100
O	13	50	...	200	50	50	50	200	...	200

N = 17% mixture = ½ nitrate of soda = ½ ammonium sulphate.

P_2O_5 = Acid Phosphate.

K_2O = Sulphate of Potash.

Experiment planned by J. A. Verret.

Experiment laid out by L. T. Lyman.

Experiment fertilized by W. W. G. Moir.

Experiment harvested by R. S. Thurston.

J. A. V.

Balsa, a New Plant Immigrant.

By H. L. Lyon.

At several points in our journey through the West Indies and Central America we came upon a striking tree which strongly suggested a large Hibiscus. In Cuba we found the tree without flowers or fruit; in Jamaica we saw a few very tall specimens in flower, and in the Canal Zone we finally obtained a few ripe fruits with abundant seeds. We were not aware of the identity of this tree until we returned to Hawaii, when we determined it to be the renowned balsa or corkwood, *Ochroma lagopus*. This discovery was very gratifying to us, for we had made a special search for the balsa and supposed we had failed to find it. Our confusion was due to the fact that we had looked for a tree to fit the description written by Bailey himself for his "Standard Cyclopedia of Horticulture." Bailey states that the fruit is one inch long, and he should have said one foot long.

The seed which we brought back to Hawaii was planted early in May, 1920, and soon yielded an abundance of rapidly growing seedlings. One of these soon pushed its roots through a crack in the bottom of a seed box and established itself in the soil below. As the box happened to be so placed that a tree would not interfere with operations in the nursery, we broke away the

Ochroma lagopus. A balsa tree growing at the Vineyard Street nursery. This tree attained a height of 15 feet in one year from seed.

seed box and allowed the seedling to remain in position without disturbing its roots, and so it has been permitted to grow without being subjected to the usual checks induced by successive transplantings and confinement in pots. The accompanying photograph was taken during May, 1921, when this tree was one year old. The tree then measured 15 feet over all and the stem was slightly over three inches in diameter three feet from the ground. The remarkable growth made by this specimen should be considered ample proof that the balsa can be grown successfully under our conditions of soil and climate.

All the rest of our balsa seedlings were held for some time in flats and then transplanted into small pots. This treatment caused them to make subnormal growth to about the same degree that the very favorable conditions in the open ground caused the single specimen described above to make abnormal growth. Fifteen of the potted trees were planted out in the H. S. P. A. arboretum at the head of Manoa Valley during February, 1921, and these are now making very strong and rapid growth. showing every indication of being well adapted to the conditions there. Some eight hundred trees were also planted out about the same time in the forests of Hawaii and Kauai, but we have no recent reports on their condition.

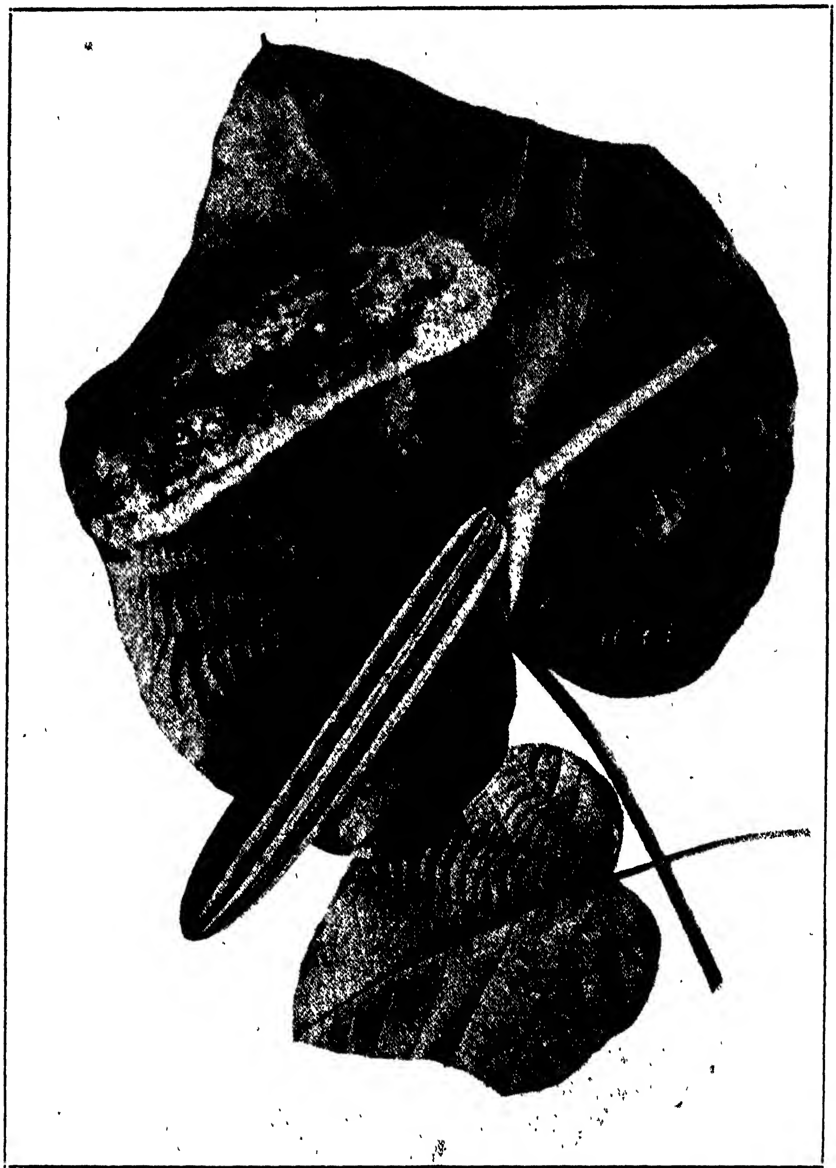
During the winter months Japanese beetles attacked and riddled the large leaves of the rank growing tree, but did little damage to the firmer leaves of the near-by potted plants in the nursery. Despite the fact that the beetles removed most of the green tissue between the veins, every bit of the tissue not actually removed remained alive and continued to function, and even after the tree had made a strong spring growth, producing an abundance of new and uninjured leaves, it still held the old perforated leaves. The photograph reproduced on page 12 shows one of these leaves as it appeared June 1.

The following description of the balsa is drawn from the literature and from the writer's notes taken in the field.

Ochroma lagopus Swartz. Family *Bombacaceae*.

An upright branching tree attaining, in exceptional specimens, a height of 60 to 70 feet and a trunk diameter of 2 feet and, in average specimens, a height of 40 to 50 feet and a trunk diameter of 1 foot; leaves orbicular cordate, entire, or three or five angled or lobed, often a foot or more broad with petioles 10 to 30 inches long, palmately veined with seven or nine primary nerves, more or less pubescent on both surfaces but more densely so beneath; flowers large, terminal; sepals five; petals five, obovate, wavy, light yellow or pale brown, 4 to 6 inches long; stamens united into a column which carries on its upper half numerous large, 1-celled anthers; ovary five-celled, each cell containing many ovules; fruit a deeply grooved, sub-cylindrical capsule, 8–12 inches long and 1 inch in diameter, splitting longitudinally into five valves; seeds very small and very numerous, closely packed in a copious soft brown wool or down which serves to buoy them up and insures their wide distribution by the wind. Native to tropical America. Common names Balsa, Corkwood, Down-tree, Ceibon Lanero, Guano, Corcho.

The balsa supplies a variety of useful products; the wood is very light but strong and elastic; the fiber or down surrounding the seeds is used in upholstering and may be spun and woven into cloth; while the bark and roots have medicinal properties.



Ochroma lagopus. Leaves and fruit. The lower fruit is still green, while the upper fruit is dry and has begun to open along the sutures, exposing the copious down which at once begins to expand, giving the fruit the appearance of a large cylindrical brush or kahili. (From the Report for 1917–1918 of the Agricultural Experiment Station of Cuba.)

In their description of balsa, Cook and Collins[1] write: "The wood is white, stained with red, luminous in aspect, sometimes silky. It is very porous and the lightest of all woods, lighter even than true cork, . . ." and they give its specific gravity as 0.12. Since the specific gravity of cork is 0.24, a cubic foot of the latter material would weigh just twice as much as a cubic foot of dry balsa wood; while a cubic foot of Douglas fir (Nor'west, sp. gr. 0.51) would weigh a little more than four times as much.

[1] Cook, O. F., and Collins, G. N., Economic Plants of Porto Rico.

It is rather strange that the balsa has not been previously introduced into Hawaii, or if it has, that it has not become established here. Producing seeds in enormous numbers and providing, as it does, for their wide distribution by the wind, this tree should spread rapidly after it has once become established on our watersheds. It should prove a very valuable component of the barrier forests which we must build along the makai borders of all our forest areas.

The Lightest Wood in the World.*

Balsa, the tropical wood lighter than cork, has already been described in these columns. According to a writer in Raw Material (New York), it is now on the American market for a variety of special uses that require buoyancy, non-conductivity for heat, smoothness, softness and lightness, and speed in working. Balsa is, so far as known, the lightest wood that grows. It averages in weight about one-third less than cork. This lightness results from its peculiar cellular structure, which is said to differ from that of any other wood. The cell walls are extremely thin; and where ordinarily there are woody fibers, there is in balsa practically no lignification. This structure confines within its large, barrel-shaped cells a quantity of "dead" air, which represents 92 per cent of the total volume of wood and which accounts for its remarkably high insulating value. To quote the article:

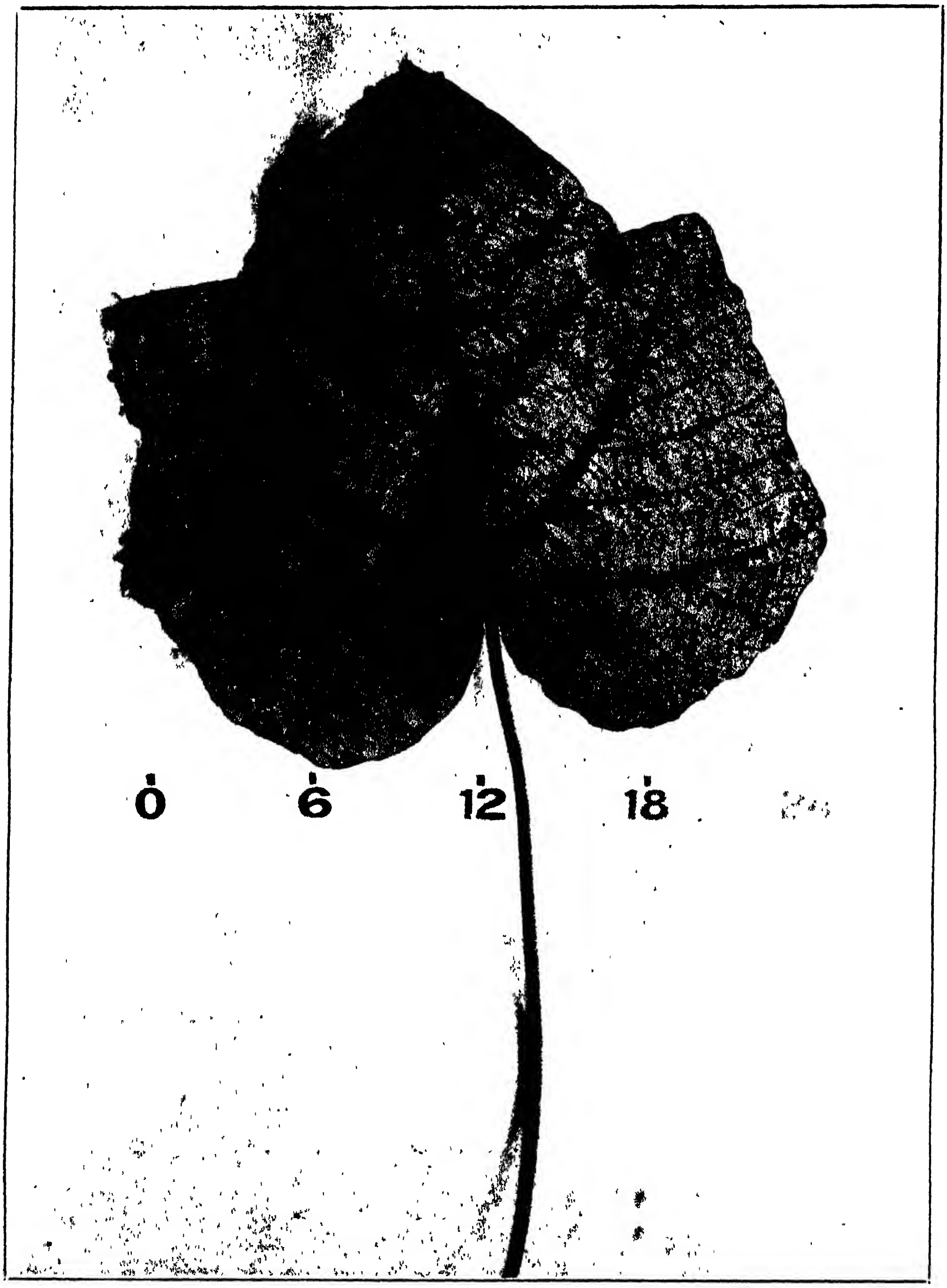
"In its natural state balsa rots quickly, and ordinary methods of preservation by painting or otherwise, are ineffective in preventing deterioration. After extended experimentation in the treatment of balsa, a process of wood preservation has been developed which meets the requirements of balsa and its uses, giving adequate protection and permanency of quality to the wood. The process thoroughly impregnates all parts of the wood with a thin coating which does not appreciably increase its weight. Treated balsa is water-resisting and is not subject to the attacks of insects or the bacteria of decay.

"Combined with its light weight and its quality of insulation against heat, balsa possesses a structural strength which, pound for pound, is greater than that of any wood. In actual test, balsa shows a strength per square inch fully one-half the strength of spruce.

"Extensive tests have shown that balsa has an insulating efficiency at least equal to that of any other commercially used product. The heat conductivity of water is such that very small percentages of moisture absorption greatly lower the quality of an insulation. Balsa is so thoroughly waterproofed that its orignal efficiency is maintained."

Treated and waterproofed, balsa is now being used, we are told, as insulating material for refrigerated spaces in over fifty ships. The early extension of its industrial use to refrigerator-cars and trucks is expected, as well as to all

* The Literary Digest for April 30, 1921.



Ochroma lagopus. A balsa leaf which has been riddled by Japanese beetles. The insects removed all of the soft tissue between the veins, but the balance of the tissue remained alive and continued to function.

insulated compartments, from small parcel-post boxes for foodstuffs, etc., to cold-storage warehouses. Insulation is, however, only one of the many uses to which balsa has already been put, and further study of its properties is constantly disclosing new directions in which it will prove of value. The writer goes on:

"Balsa first attracted attention by reason of its light weight, which suggested its use in life-preservers and other equipment for saving lives at sea. During the war, large numbers of balsa rafts, elliptical rings of solid, treated balsa, waterproofed and covered with canvas, were a familiar part of the safety equipment carried on board the American transports. Balsa fenders are used on two types of life-boats. The great buoyancy of this wood has also been made use of in a line of water sporting goods, such as surf boards and decoys.

"Excellent proof of the effectiveness of the waterproofing treatment was shown during the war by the 70,000 mine-buoys whose use largely made possible the 250-mile 'mine barrage' across the North Sea. This was said to be the only type of float which could withstand the long submersion and the crushing effect of depth charges.

"Of the miscellaneous uses dependent upon its light weight, balsa has already been successfully employed in the construction of hydroplane pontoons and for filling out stream-lines of airplane struts.

"The smoothness and softness of balsa have led to its increasing use in the protection during shipment of highly finished furniture surfaces, such as phonographs and pianos. Not only is the wood smooth, but it has remarkable elasticity, and this is not in the least altered by subsequent compressions.

"The facility and speed with which treated balsa may be worked either by hand or with wood-working machinery have made it particularly adaptable to use in toy manufacture, such as toy airplanes. It has also been used for the throats of phonographs, which in certain makes must be hand-carved."

[H. L. L.]

The Production of Dairy Roughages for Hawaiian Plantations.

By John H. Midkiff.

A number of plantations in various parts of Hawaii are operating dairies, or are planning to do so. For the economical production of milk, a constant supply of good roughage is absolutely essential. It makes no difference what concentrates may be fed, a cow must have plenty of roughage to do well. The questions before several plantation men now are: "What shall these roughages be? What feeds, adapted to my soil and climatic conditions, can I raise that will give me the biggest returns in milk?"

Where alfalfa can be easily raised, without too great a drain upon the labor

supply, and at a reasonable cost, it is the ideal dairy crop. Cows will probably produce more milk on it than on any other roughage that can be raised. But it is, in many places, hard to raise. It needs considerable attention,—weeding and irrigating,—and is much more easily killed out by certain pests than some of the other forages produced here. Alfalfa is now being raised successfully on all of the principal islands. In most cases it is irrigated. Men who are not in a position to irrigate this crop should not plant a very large area of it, unless the rainfall is large and fairly constant. It will not do well in a sour soil, and it should not be planted where the water table is so near the surface that good drainage is impossible.

Considering the fact that alfalfa does require so much attention, that it is not as hardy as some other forage plants, and that some growers who now have good stands of the plant are finding it more profitable to grow other leguminous roughages than to weed and irrigate the alfalfa, we do not recommend it for most plantations. However, if the planter is willing to devote to this crop the labor and money that it requires, he will get the best dairy roughage obtainable.

We believe that the pigeon-pea, if fed in conjunction with certain other bulky roughages, is one of the best and safest leguminous crops for this purpose. This plant contains a high percentage of protein. Actual feeding tests have shown that it is a wonderful milk producer. It is comparatively easy to raise and requires little attention, once the plant is well started. It bears heavily and cows like few feeds better.

Perhaps the best recommendation that we can give the pigeon-pea is the fact that men who gave it a trial a year or two ago, are now spreading the crop rapidly. Many are now planting a strain developed by F. G. Krauss at the Haiku Substation of the United States Experiment Station. This variety bears very heavily and matures early, and we would strongly recommend it to anyone who intends to plant pigeon-peas, as we believe it to be the best now obtainable.

Pigeon-peas are easily raised. After the soil is well prepared the seed should be drilled in rows at the rate of ten or twelve pounds per acre. If the soil is very dry an irrigation or two will help germination. The crop should be given considerable attention until it has made a good growth. When it is well started, however, its hardiness is remarkable. It chokes out many weeds and makes a fair growth, even when given no cultivation. When it gets four or five feet tall it can be cut off about a foot above the ground, and the entire plant—leaves, seed pods, stalks and all—run through a cutter and fed. Shoots will start from the stumps and about two months later another crop can be removed. This ratooning can be continued successfully, under normal conditions, for years. Many dairymen pasture the plant and cut it back only when it gets ahead of the animals and gives indication of becoming too woody.

Since pigeon-peas make a highly nitrogenous feed, best results will be obtained by feeding with it some nonprotein roughage, such as Sudan grass, Elephant grass, cane tops or Uba cane. If good, fresh, green cane tops can be secured they are entirely satisfactory. These are also successfully fed as silage at Kekaha, and dried and baled at Hawaiian Commercial & Sugar Company. As a feed for dairy animals, experience would indicate that the fresh tops or the silage would be superior to the cured and baled material.

Many plantations cannot get good cane tops at all times, however, and some do not care for cane tops either as silage or as dried hay. Under such conditions Elephant or Napier grass affords a good substitute. This grass grows well under a wide range of conditions. It will grow near the beach, providing the salt spray does no strike it too much, and it does well, better than most green fodder crops, at fairly high altitudes. It is high in carbohydrates and low in proteids. Pigeon-peas and alfalfa are high in proteids and low in carbohydrates. Chopped and fed together, pigeon-peas or alfalfa and Elephant grass make very nearly an ideal roughage for dairy cows.

Elephant grass is a cane-like, non-saccharin grass. Cuttings may be planted in the same manner as those of the sugar cane or they may be planted at a slant in the furrows with one joint left above ground. The former method is probably the better of the two. If the seed is planted end to end, in rows four or four and a half feet apart, and covered about two inches deep, a heavy growth should result, providing good seed is used. The seed should be taken from well matured canes. It is not essential that top seed only be used, as body seed is perfectly satisfactory, providing care be taken to avoid injured and dried-out eyes.

Elephant grass may be pastured or the grass may be cut when it is about five feet high, chopped up and fed to the animals. The grass should be cut close to the ground, just as cane is. If cut in this manner and given proper care, this crop will give more feed per acre than if pastured. If pastured it should be allowed to grow at least four feet high before the cattle are turned in, and it must not be pastured so heavily that the animals kill it out. On the other hand if not enough cows are pastured on it to keep it down fairly well, too large and coarse growths will be made and it will be necessary to cut the woody canes back occasionally.

While we believe that Elephant grass is about the best grass to raise, under general conditions, to supplement the leguminous forage plants, there are other grasses that do fairly well, such as Sudan grass or Uba cane. The Uba cane grows more slowly and yields less under normal conditions than does the Elephant grass. At the Haiku Substation, F. G. Krauss found that Elephant grass matured in half the time required for Uba cane, and the Uba cane when it did mature produced only half as large a crop; thus the Elephant grass produced four times as much feed as the Uba cane. But it is generally believed that Uba cane will do better than Elephant grass under unfavorable conditions. So on very dry soils, on very wet and heavy soils, on lands near the beach where the salt breezes hit the cane, and at very high altitudes, the Uba cane would probably give better results and a larger yield than the Elephant grass.

Sudan grass is a smaller, finer plant than Uba cane or Elephant grass, and it cannot be expected, under ordinary conditions, to produce as much per acre. It is now being raised and fed with good results, supplementing alfalfa, to several herds of dairy cows in Hawaii. If produced under very dry conditions, Sudan grass, as well as nearly all other sorghums, may develop prussic (hydrocyanic) acid, which is very fatal to livestock. This point must be carefully watched in feeding any kind of sorghum roughages.

An experiment conducted by Mr. Krauss at Haiku on the feeding of Yellow Tip cane to dairy cattle is of interest. He found that this cane, under condi-

tions which practically prevented the growth of forage plants, made an exceptionally good dairy roughage. It was of course necessary to cut the cane before it became too hard and woody. Then, instead of employing the ordinary feed cutter, the cane was shredded so as to leave no large pieces of woody fiber for the cows to eat. The first crop was cut about four months after planting, the succeeding crops requiring about the same time, making three crops a year. Mr. Krauss found that he got more feed by cutting three times a year than he did by cutting four times. The cane may be ratooned, under this system, a great many times, providing it is given reasonable cultivation, irrigation, and ferilization.

Too many people think that sugar cane is the only crop in Hawaii that requires fertilizing. Cane can be grown without fertilizers, but maximum crops of it are not obtained under such conditions. The same is true of grasses and other forage crops. It will often pay to fertilize pigeon-peas and Elephant grass. Since the grasses are cut more often, smaller and more frequent doses of nitrogen will undoubtedly be more practical than one big dose a year. A little close observation upon the effect of various sized doses given at different times will give the planter much information on this point.

Before planting these forage crops it will be a good insurance to add some phosphates to the soil. Reverted phosphate or a mixture of half reverted and half acid phosphate applied at the rate of 500 or 600 pounds per acre will not cost much and might be beneficial. Mr. Krauss reports from Haiku, Maui, that he got good returns from the use of phosphates in this manner, whether applied to soils high or low in phosphorus.

Value of Press Cake and Varying Amounts of Fertilizer.

Waipio Experiment U, 1921 Crop.

This was an experiment to determine the value of press cake in increasing crop yields when used without fertilizer and with varying amounts of fertilizer. A comparison was also made between varying quantities of fertilizer.

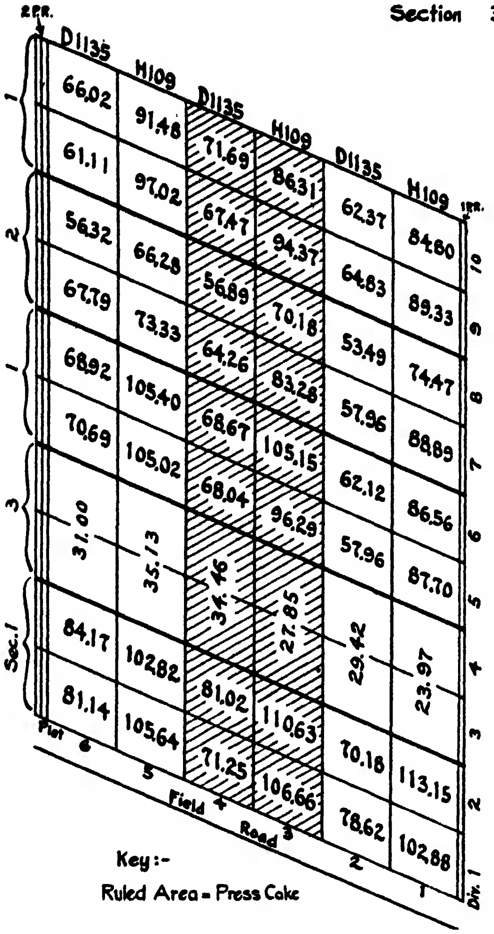
The cane was D 1135 and H 109, 4th ratoons, long, and was 21 months old at harvest, not having been cut back.

A uniform application of 10 tons per acre of press cake was made to a portion of the plots. The cane had not been hilled. A small trench was dug along one side of the cane row, where the press cake was applied and then covered. A number of press cake plots received no further fertilization; another portion received nitrogen only, at the rate of 135 pounds per acre (870 pounds nitrate of soda), while the remaining plots received nitrogen at the rate

VALUE OF PRESS CAKE & VARYING AMOUNTS OF FERTILIZER.

Waipio Experiment U, 1921 Crop

Section 35.



Variety	Treatment	Tons Cane Per Acre	Gain Due To Mud Press
H 109	10 Tons Mud Press + No Nitrate of Soda	35.1	
H 109	No Mud Press + No Nitrate of Soda	25.9	+ 9.2
D1135	10 Tons Mud Press + No Nitrate of Soda	34.5	
D1135	No Mud Press + No Nitrate of Soda	30.2	+ 4.3
H 109	10 Tons Mud Press + 870# Nitrate of Soda	76.7	
H 109	No Mud Press + 870# Nitrate of Soda	75.8	+ 0.9
D1135	10 Tons Mud Press + 870# Nitrate of Soda	60.5	
D1135	No Mud Press + 870# Nitrate of Soda	58.9	+ 1.6
H 109	10 Tons Mud Press + 1740# Nitrate of Soda	100.1	
H 109	No Mud Press + 1740# Nitrate of Soda	97.7	+ 2.4
D1135	10 Tons Mud Press + 1740# Nitrate of Soda	71.4	
D1135	No Mud Press + 1740# Nitrate of Soda	69.0	+ 2.4

of 270 pounds per acre (1740 pounds nitrate of soda). The nitrate of soda was in all cases applied in two doses—two-thirds in August, 1919, and one-third in February, 1920.

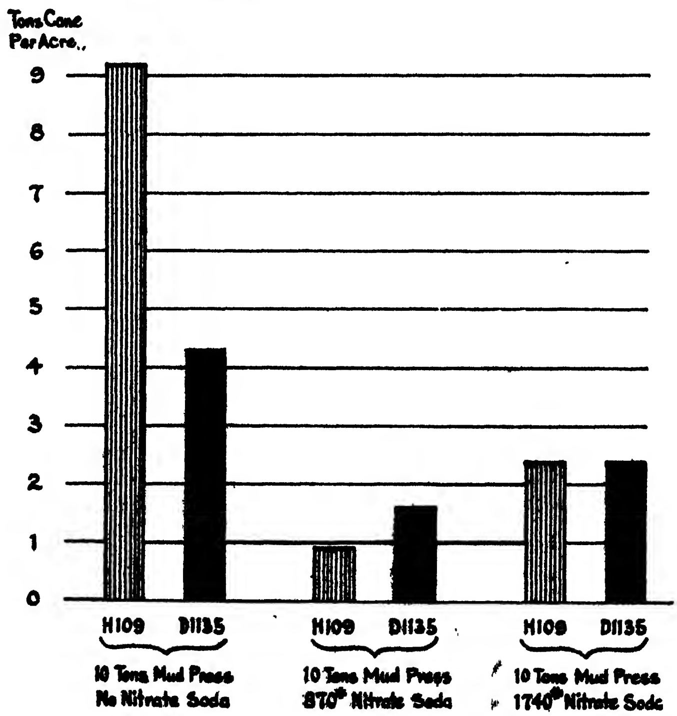
It was not possible to take "car samples" of juice at the mill. The sugar yields are therefore not given here, as small hand mill samples are not considered sufficiently reliable.

The yields of cane per acre for the different treatments are given as follows:

Variety	Treatment	Tons Cane per Acre	Gain Due to Press Cake
H 109	10 tons P. C. + no N. S.	35.1	
"	No. P. C. + no N. S.	25.9	+9.2
D 1135	10 tons P. C. + no N. S.	34.5	
"	No. P. C. + no N. S.	30.2	+4.3
H 109	10 tons P. C. + 870 lbs. N. S.	76.7	
"	No. P. C. + 870 lbs. N. S.	75.8	+0.9
D 1135	10 tons P. C. + 870 lbs. N. S.	60.5	
"	No. P. C. + 870 lbs. N. S.	58.9	+1.6
H 109	10 tons P. C. + 1740 lbs. N. S.	100.1	
"	No P. C. + 1740 lbs. N. S.	97.7	+2.4
D 1135	10 tons P. C. + 1740 lbs. N. S.	71.4	
"	No P. C. + 1740 lbs. N. S.	69.0	+2.4

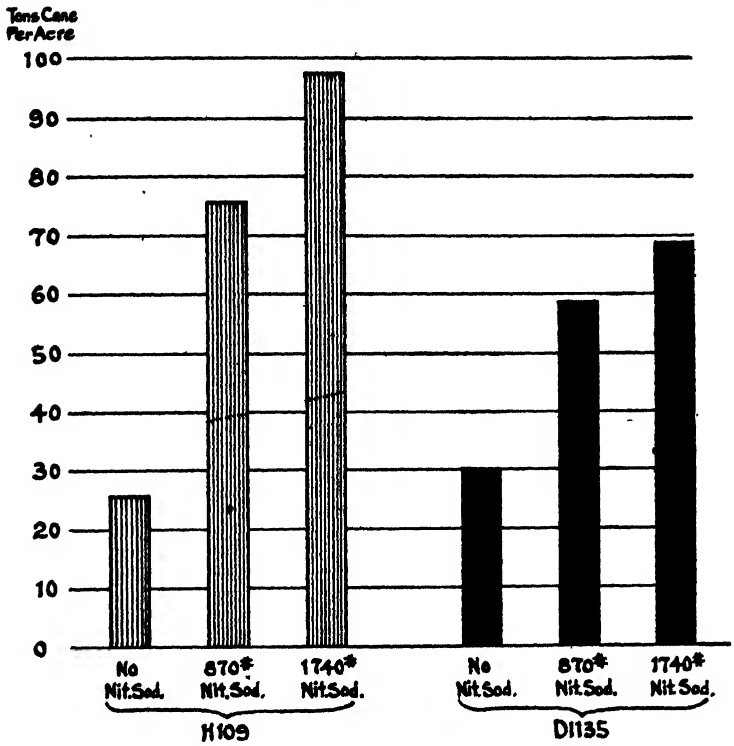
Chart Showing Gains Due To 10 Tons Of Mud Press Per Acre In Addition To Varying Amounts Of Nitrate Of Soda.

Waipio Experiment U, 1921 Crop



These results indicate the value of 10 tons per acre of press cake to be from 5 to 10 tons of cane when no other fertilizer is used. With medium to heavy fertilization the gains are much less. We see from these results that press cake cannot be expected to take the place of readily available plant food from commercial fertilizers, unless, perhaps, where press cake is used in enormous quantities. It would seem to us that the proper way to get the most value

AMOUNT OF FERTILIZER
Waipio Experiment U, 1921 Crop



from this material would be in its use on the very poor fields only and in "building up" bad spots in the more accessible parts of the plantation.

The results obtained from the use of varying amounts of nitrate of soda are given below:

Treatment	Tons Cane per Acre	
	H 109	D 1135
No nitrate of soda....................	25.9	30.2
870 lbs. nitrate of soda................	75.8	58.9
1740 lbs. nitrate of soda................	97.7	69.0

The most striking thing about these results is the different behavior of the two varieties under the different treatments. Without fertilizer D 1135 was slightly better than H 109, while under intensive fertilization H 109 produced one-third more cane and about double the sugar produced by D 1135 under the same conditions.

Experiment planned by J. A. Verret.
Conducted by R. M. Allen.
Harvested by A. Paris.

J. A. V.

Nitrogen, Phosphoric Acid, and Potash.

WAIPIO EXPERIMENT V, CROPS 1917, 1918, 1919, AND 1920.

This was an experiment to determine the values of nitrogen, phosphoric acid and potash, alone and in different combinations, for soils of Waipio. The canes involved were Yellow Caledonia and D 1135. This experiment has now been carried on through four crops without change. The crop just harvested was fourth ratoons, so the field was plowed and planted to H 109. The different fertilizer treatments will be continued unchanged.

The X plots received 150 pounds of nitrogen, 75 pounds of phosphoric acid and 75 pounds of potash per acre. The A plots received nitrogen only at the rate of 150 pounds per acre; the B plots received the same amount of nitrogen plus 75 pounds of potash; the C plots the same nitrogen treatment plus 75 pounds of phosphoric acid instead of potash; the D and E plots received no potash or phosphoric acid, but 200 and 250 pounds of nitrogen per acre, respectively.

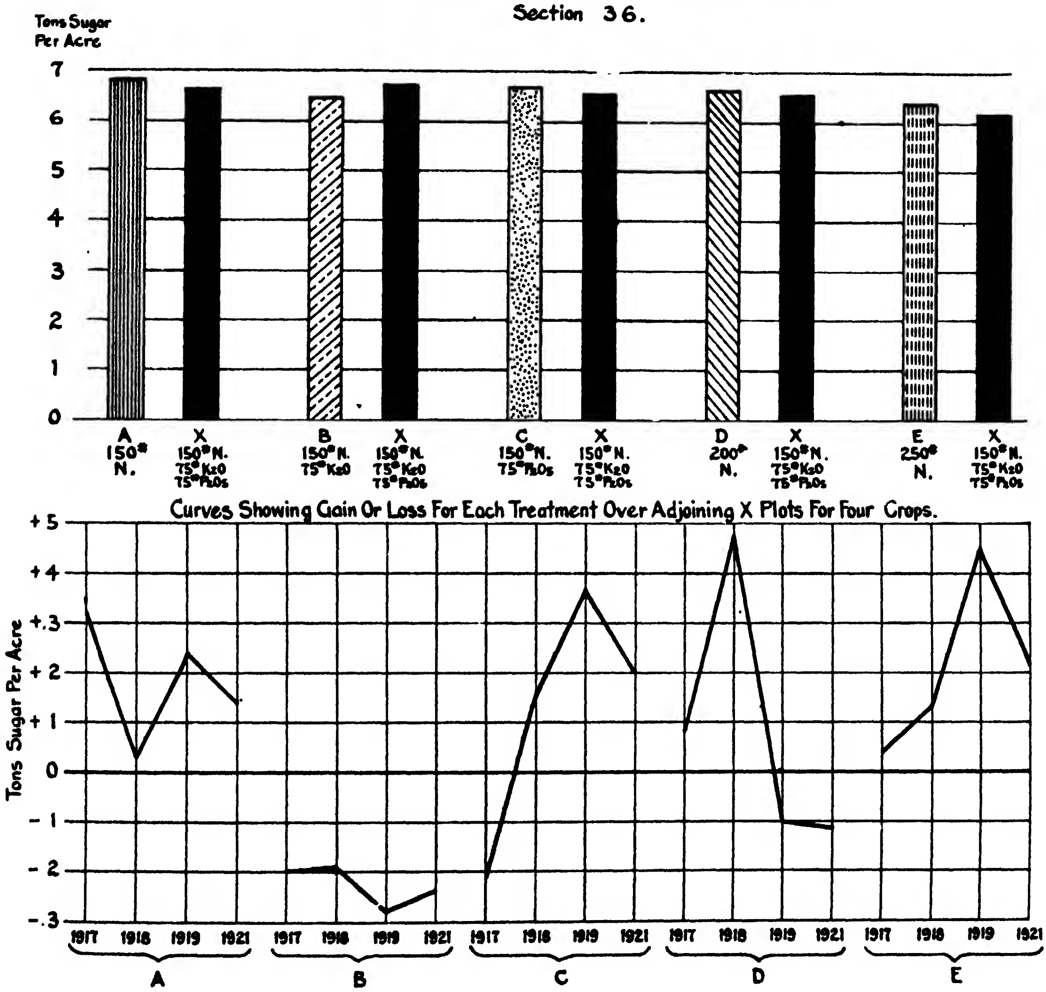
The results obtained from the four crops show no great variations for the different treatments. In no case was the difference in yield much greater than would normally occur were all the plots receiving similar treatment.

The results obtained from the four crops harvested are given in tabular form as follows:

Plots	Treatment	Tons of Sugar per Acre				
		1917 S. R.	1918 S. R.	1919 S. R.	1921 L. R.	Average
A	150 lbs. N.	6.20	5.80	6.08	9.31	6.84
X	150 lbs. N. 75 lbs. P_2O_5, 75 lbs. K_2O	5.88	5.77	5.84	9.17	6.67
B	150 lbs. N. 75 lbs. K_2O	5.86	5.76	5.82	8.64	6.51
X	150 lbs. N. 75 lbs. P_2O_5, 75 lbs. K_2O	6.06	5.95	6.10	8.88	6.75
C	150 lbs. N. 75 lbs. P_2O_5	5.52	5.99	6.17	9.25	6.72
X	150 lbs. N. 75 lbs. P_2O_5, 75 lbs. K_2O	5.73	5.83	5.80	8.95	6.58
D	200 lbs. N.	5.50	6.04	6.07	9.14	6.68
X	150 lbs. N. 75 lbs. P_2O_5, 75 lbs. K_2O	5.42	5.56	6.17	9.25	6.60
E	250 lbs. N.	4.87	5.84	5.95	9.10	6.44
X	150 lbs. N. 75 lbs. P_2O_5, 75 lbs. K_2O	4.83	5.71	5.50	8.88	6.23

In a broad way these results would indicate that nitrogen is the limiting factor in Waipio soils and that they require very little, if any, phosphoric acid and potash. But a close study of the results (see series of curves on page 21) tends to point to the need of some phosphoric acid, while potash is of no value whatever. This is seen by comparing the B and C plots. Dropping phosphoric

CHART SHOWING AVERAGE YIELD OF EACH TREATMENT FOR 4 CROPS
Waipio Exp. V, 1917, 1918, 1919 & 1921 Crops
Section 36.



acid (B plots) caused a loss as compared to complete fertilizer, but phosphoric acid and nitrogen (C plots) gave better yields than the complete fertilizer, and the gains were greater during the last two years than during the first two, showing a growing need for phosphoric acid.

This experiment will be continued to determine how long maximum crops can be grown on this soil with nitrogen alone, and then should be continued to note how fast crop production drops when either phosphoric acid or potash, or both, becomes the limiting factor.

DETAILED ACCOUNT.

Object:

1. To find the relative value of nitrogen, phosphoric acid and potash on ratoons of Yellow Caledonia and D 1135.
2. To find the immediate and ultimate effect of omitting phosphoric acid or potash, or both, from the fertilizer applied.

Location:

Waipio Substation, Section 36.

Layout:

Sixty plots, each 1/30 acre net, 8 rows to each plot.

Plan:

Fertilization Pounds per Acre

Plots	No. of Plots	Nitrogen	Phos. Acid	Potash
A	6	150 lbs.	0	0
B	6	150 lbs.	0	75 lbs.
C	6	150 lbs.	75 lbs.	0
D	6	200 lbs.	0	0
E	6	250 lbs.	0	0
X	30	150 lbs.	75 lbs.	75 lbs.

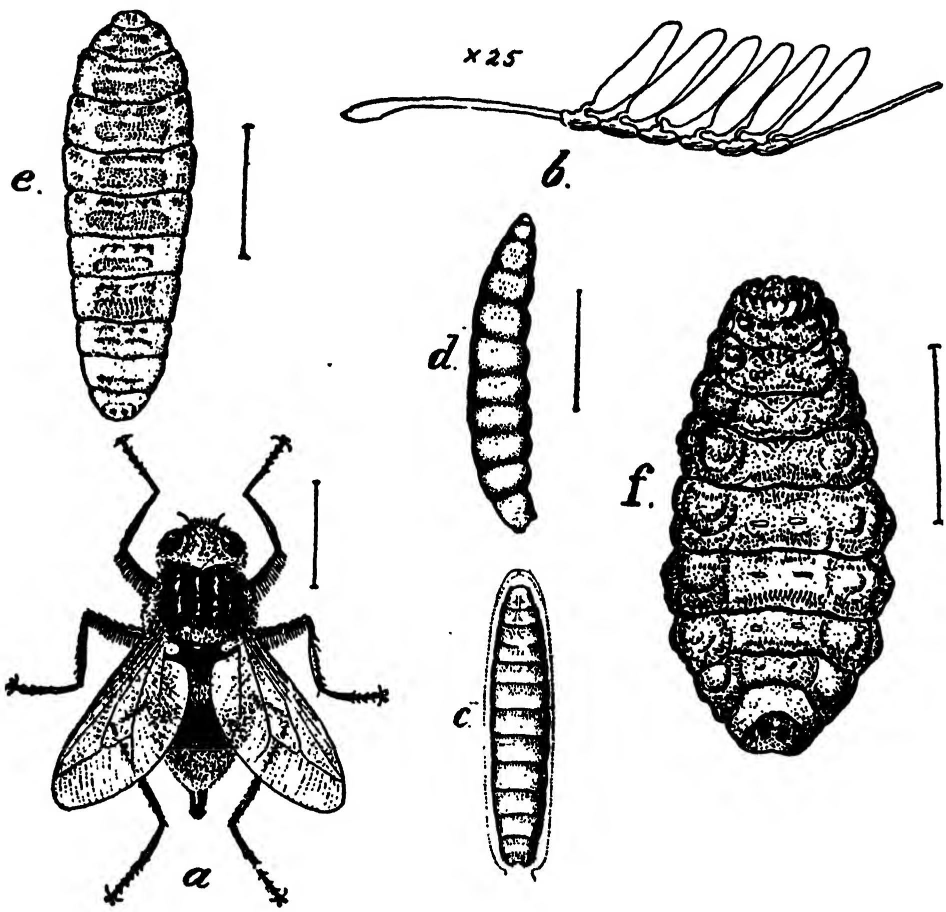
J. A. V.

Ox Bot-Fly or Warble Fly, Hypoderma Lineata.

By O. H. Swezey.

While on the Island of Kauai, May 3 to 7, 1921, I saw cows with warbles in their backs in dairies on two different sugar plantations. In one of the dairies only a very few were observed; but in the other dairy several of the cows were infested with warbles. One cow had half a dozen of them.

These cows had lately (four to six months previously) been imported from the mainland, and no doubt were infested with the warbles before they were



The warble fly (*Hypoderma lineata*): *a*, adult female; *b*, eggs attached to hair, × 25; *c*, larva as seen in egg; *d*, larva from esophagus of an ox; *e*, next stage of larva from beneath the skin of the back; *f*, larva at the stage when it leaves the back of host and falls to the ground. All enlarged (after Riley.)

shipped. Different ones who had had more or less to do with cattle for some years said that they had never found any of the warbles in cattle raised on Kauai. Hence it can be inferred that this fly has not become established there, though it may have had opportunities to do so from cattle that were already infested when imported. No doubt this has occurred many times similarly to the present instances.

As the warble maggots may be present in their host for several weeks or a few months without developing sufficiently to be noticeable, it is easily possible that infested cows could be brought in without it being known till later on, when the maggots had developed enough to produce the lumps and ulcers on the animals' backs.

This pest is a large fly, somewhat related to the bot-fly of the horse. Like it, the adult fly lays its eggs on the hairs of the host animal, usually on the shoulders, front legs near the heel, or other parts where they will be licked by the animal and thus gain entrance by way of the mouth. The young maggots bore through the wall of the gullet, and gradually work their way through the tissues up to the back, where they finally grow and produce noticeable swellings, which finally become ulcers and make perforations in the skin, from which the large, full-grown maggots emerge and fall to the ground. They bury themselves in the ground for pupation, and after three to six weeks issue as adult flies.

In the temperate climate of the United States the eggs are usually laid in early summer. The larva is well developed when the egg is laid, and when the cattle lick themselves the young larvae are removed from the eggs and taken into the mouth. They are armed with many minute spines, which permit them to adhere to and to penetrate the walls of the esophagus. For several months they wander slowly in the tissues of the host, eventually in late winter reaching a point beneath the skin in the region of the back. The growth has been slow up to this time, but now it becomes more rapid, and soon are formed the strongly spined grubs which occupy the swellings or ulcers so conspicuous on the backs of infested cattle. They become full grown in the spring months and issue from the perforations or openings of the ulcers to pupate in the ground. This occurs from March to May, and the mature flies appear about a month later, being most abundant in the Central States in July or August. Eggs are then laid for the next generation, there being but one generation per year.

If these flies should become established in the dairies and cattle ranges of the Hawaiian Islands, their breeding might not be so seasonal, and possibly there would be more than the one brood per year. Perhaps their life cycle might be shortened and it might be that they would develop continuously without respect to seasons, as do the house-fly and horn-fly.

This pest causes a gerat deal of loss to cattle in the States. At many of the beef packing houses the value of the hides is greatly reduced, often one-third, and the meat is also spoiled in the regions occupied by the warbles; thus many thousands of dollars' loss occurs. They are also very deleterious to dairy cows when abundant.

There are no definite records of these flies having become established in the Hawaiian Islands. None of the insect collections have specimens of the flies collected here.

In the Annual Report for 1907 of the Hawaii Agricultural Experiment Station, Van Dine says, in listing cattle pests:

> "Possibly these flies have been brought to Hawaii with imported cattle from the western coast of the mainland. But apparently they have not become established."

In a report to the Hawaiian Live Stock Breeders' Association for the year 1907, Dr. Norgaard and Van Dine mention the warble fly as a cattle pest which does not seem to become well established here, being apparently controlled by some natural enemy. In this report it is stated that, "Though no regulation has been promulgated to that effect, the office of the Territorial Veterinarian has made it a rule to thoroughly disinfect the hides of all imported cattle immediately after arrival and to destroy all warbles which at that time have made their appearance under or in the hide."

In the Proceedings of the Hawaiian Entomological Society, III, page 113, 1915, is a note by Mr. Ehrhorn, relative to observations made by him several years previously on Molokai. He is reported as saying that the work of this fly is only occasionally observed on Molokai and the large numbers of ants on the cattle ranges destroy the larvae as they emerge and fall to the ground to pupate.

Whether established here or not, or whether kept well controlled by some natural enemies. it is advisable to destroy all warbles that are found in imported cattle, so as to prevent or lessen the chances of their becoming established on the cattle ranges of our Islands. Besides, imported cattle are usually of high valuation, and for their sakes close examination should be made for warbles and destroyed wherever found. They may be destroyed by pressure or by insecticidal treatment. When the perforation in the skin is large enough, the maggot may be forced out by careful pressure, and stepped on when it falls to the floor or ground. If necessary, the opening may be enlarged a little by using a round stick bluntly pointed, as a probe. If the opening is very small, the maggots may be killed by rubbing in a little kerosene or the application of mercurial ointment. as they have their breathing pores directed towards the opening and would easily succumb to the treatment. It thus becomes an easy matter to destroy these pests in cows which are under daily observation, as in milking sheds, and all stable men should become familiar with the manner of recognizing the presence of the pests and the methods of relieving the cattle of their annoyance. It should be an easy matter to rid a herd of them if these precautions are taken.

The Inheritance of Productivity in Potatoes.*

According to a note published in the Indian Scientific Agriculturist, November, 1920, from his investigations conducted in Germany into the inheritance of productivity in potatoes in connection with the choice of tubers for planting purposes, C. von Steelhorst came to the conclusion that the size of the tubers used for planting has a decided influence on the yield of the descendants, the large tubers being usually more productive than the small ones. The pro-

* *Agricultural News, West Indies,* Vol. XX, No. 493. 1921.

ductivity of parent plants, however, appears to be of even greater importance, for in the tests made, small tubers from productive parent plants nearly always gave more productive descendants than those of large tubers from slightly productive plants. For example, whereas the smallest tubers (average weight 33 grams) of productive plants had descendants that yielded on an average, 518 grams of tubers per plant, the relatively large tubers (average weight 84 grams) of poor productive plants had descendants that produced only an average of 88 grams of tubers per plant. [J. A. V.]

Potato Improvement by Hill Selection.*

The Utah Agricultural College Experiment Station has recently issued a bulletin by Mr. George Stewart on "Potato Improvement by Hill Selection."

This bulletin reports the results of potato selection through a series of years. The work was started in 1911 and is still being continued. The results reported show large gains in yield for the good selected progenies.

There is a close similarity between the methods of propagation of the sugar cane and of the potato, both being done by means of cuttings. There is, therefore, no reason to doubt but that similar results will be obtained with sugar cane if the work is carefully done.

The methods of selection used at the Utah Station are identical with those we are using in the selection of sugar cane.

The results reported in the bulletin are briefly abstracted as follows:

After giving a review of the literature Stewart gives the following plan of the experiment:

> "In 1911 a number of the highest-yielding hills, and also of the lowest-yielding hills, were selected from the Majestic, Bangor, and Peerless varieties, then being grown at the Utah Station. Each hill was put in a separate paper bag and numbered. In 1912 the tubers from each hill were cut into sets weighing approximately two or three ounces and containing on the average two eyes. The sets were planted about 15 inches apart with rows three feet apart. The row thus planted from the sets of each hill was marked with a numbered peg and regarded as a unit. No effort was made to keep the sets from each tuber separate from those of other tubers in the same hill.
>
> "At harvest time each hill was dug separately and the tubers placed in a paper bag. During the fall and early winter the tubers from each hill were weighed, counted, and returned to their bag for storage until the data for the progeny-rows were all calculated. The poorer rows in the good selections were all discarded. About half of the best hills from the best progeny-rows and a few high-yielding hills from the other good rows were chosen for planting the next spring. In the poor selections the lowest-yielding hills were used as seed. The same sort

* Bulletin No. 176, by George Stewart.

of selection was continued from 1912 to 1919 and is being further continued and supplemented, except that the poor selections were discarded in 1916."

By the year 1916 all the progenies selected in 1911 had been discarded except one, that of hill No. 25. The strain represented by hill No. 25 was found to be the best, that progeny giving the highest yield, yet in 1911 this particular hill was surpassed by 24 other hills out of 29. This shows the importance of a careful study for several of the different selections so as to determine which ones have the power of transmitting their superior characteristics to their progenies. In this way the different strains in the variety may be separated.

The results of the selections are studied and summarized as follows in the bulletin:

Analysis of Data.

"In Table XII are given the summary data for the pedigree selection Mg 25–1–9–20–3–15 and for the unselected stock for the years in which it was grown as a check, 1915 to 1920, inclusive.

"The pedigree-selected strain produced somewhat more than a hundred bushels higher yield than did the unselected strain, except in the year 1919, when the yield was only 29.6 bushels greater. The yield to the hill was about in the same proportion as the acre-yield, except in the year 1919, when the pedigree strain yielded 358 20 grams to the hill as compared with 270.20 grams for the unselected. With the unselected yield at 117 bushels, the pedigree stock should have yielded 156 bushels, but it made only 147 bushels, due to low yield of the pedigree strain 3–15–10, on which the stand was poor. Attention has already been called to the fact that 1919 was highly unfavorable for potatoes.

TABLE XII.—SUMMARY DATA FOR THE PEDIGREE SELECTION MG 25–1–9–20–3–15 AND FOR THE UNSELECTED STOCK 1915–1920, INCLUSIVE.

Year	Pedigree Selection Mg 25-1-9-20-3-15		Unselected Stock		Gain Over Unselected (bushels)
	Weight to the Hill (grams)	Acre-yield (bushels)	Weight to the Hill (grams)	Acre-yield (bushels)	
1915	1050.91	316.7	643.02	179.3	137.4
1916	839.40	330.7	583.70	191.2	139.5
1917	810.66	382.4	698.39	269.3	113.1
1918	771.57	311.9	580.11	202.4	109.5
1919	358 20	146.9	270.20	117.3	29.6
1920 *	962.12	353.4	517.60	184.8	168.6
Average	789.61	307.0	548.83	190.7	116.3

* At the time of publication only the yields for the 1920 harvest had been obtained. The other data required three or four months for tabulation and calculation.

TABLE XIII.—SUMMARY DATA FOR PEDIGREE STRAIN MG 25-1-9-20-3-15 AND FOR THE UNSELECTED STOCK WITH RESPECT TO NUMBER OF TUBERS TO THE HILL AND THE AVERAGE SIZE OF TUBER, 1915-1919, INCLUSIVE.

Year	Pedigree Selection Mg 25-1-9-20-3-15		Unselected Stock	
	Average No. Tubers to the Hill	Average Weight to the Tuber (grams)	Average No. Tubers to the Hill	Average Weight to the Tuber (grams)
1915	5.84	182.11	4.48	143.56
1916	4.58	184.20	3.84	152.80
1917	5.22	153.39	4.50	151.63
1918	4.10	187.43	4.49	127.87
1919	3.83	112.38	3.26	82.83
Average	4.89	163.90	4.14	131.74

"The number of tubers to the hill is greater and the average size of tubers is larger in the pedigree strain than in the unselected. Table XIII, which contains a summary of these data shows that there is an appreciable difference in these two respects.

"There is an increase in the average number of tubers to the hill from 4.14 to 4.89 in favor of the pedigree strain, or 18.1 per cent. In average size of tuber there is an increase from 131.74 grams for the unselected to 163.90 grams for the pedigree strain,—a gain in size of 24.4 per cent. Both of these increases are desirable.

"As a six-year average, from 1915 to 1920, inclusive, there is a gain in acre-yield of 60.9 per cent, and a further gain of 24.4 per cent in average size of tuber. Although the percentage of marketable tubers was not recorded throughout the experiment, it seems safe to conclude that an increase of 24.4 per cent in size of tuber means an appreciable gain in percentage of marketable tubers. The last two years, the only ones in which the percentage of the marketable tubers was obtained, show 78.6 per cent marketable for unselected stock and 90.5 per cent for the pedigree-selected strain, a gain of 11.9 per cent for the selected strain.

Discussion of Results.

"Merely to select high-yielding hills has not been effective in this experiment, because many such hills have produced progeny rows of only mediocre quality. Early in the experiment it was found necessary to test the power of selected hills to transmit their quality to the next generation.[1] A good hill may have become such not because of any inherent virtue in itself, but because of having had more favorable surroundings, such as more fertile soil, more moisture, or more room in which to grow.

[1] The italics are ours and were used to indicate what we regard as essential to the success of work of this kind.

"J. Arthur Harris [2] of the Carnegie Institution has marshalled many data that show even the most uniform soils to be highly variable. F. S. Harris [3] of the Utah Station demonstrated that both too little and too much moisture in the soil produced lower yields of potatoes than the more favorable medium degree of wetness. Stewart [4] found that missed hills gave an appreciable advantage to both adjacent hills. In this experiment, with hills planted 15 inches apart, one missed hill increased the yield of each neighbor 23.2 per cent, or 46.4 per cent for the two. From the above, it is apparent that one potato hill may far outyield a neighboring hill owing to some environmental advantage. Because selection of such a hill is made on purely *somatic* characters, that is, body characters that are visible, it is not possible to predict the extent of transmission of the selected quality to its offspring.

"On the other hand, when the selection can be so made as to select for an inherent quality, that is, for a *gametic* character, then a fair degree of transmission may be expected. So far as the nature of material permitted, this was the type of selection that has been followed during the experiment here reported. To accomplish this, it was necessary to delay selection until the second year, or even until later years, in order to tell whether a given potato mother-hill had the power to transmit its yielding power to the daughter-hills and thereby leave its imprint on the race. Such plant-breeding is not far removed from the problem a cattle breeder is attempting to solve when he chooses a sire for his herd.

"In the beginning, when the three varieties were being tested, Bangor and Peerless were not discarded at once, but were carried three years in order to make sure that the Majestic had not produced a higher yield merely on account of some environmental advantage. The 1913 crop showed a considerably higher yield for hill Mg 25 than for any other progeny. It was only after this test that the other strains were discarded. In fact, had not transmission tests been used this hill would have been discarded two seasons previously, because in 1911 it was surpassed in yield by 24 other hills out of a total of 29. The history of this hill illustrates both sides of transmission: (1) a hill ranking only twenty-fifth in 1911 gave progeny in 1912 that was better than any other; (2) in 1913 it was again tested against two others of the best progenies and again produced the highest yield. It was, therefore, concluded that here was a strain that carried at least some inherent high-yielding qualities. When the 1915 harvest permitted, for the first time, a comparison with the unselected bulk strain of the same stock the yield was 301 bushels as compared with 179 bushels for the unselected.

"The 1919 harvest may have given cause to question the superiority of the selected strain, for after showing an increased yield of about a hundred bushels for four years, the selected progeny suddenly relapsed to a yield of only 29.6 bushels greater than that of the unselected strain, but this was a gain of 25.2 per cent. During 1920, there was a decidedly better stand, an earlier start, a thriftier growth, and greater freedom from disease in the selected stock. In every way the pedigreed strain promised to be much better. The gross acre-

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[2] Jour. Agr. Rsch., Vol. 19, No. 7, pp. 279–314.

[3] Utah Exp. Sta. Bul. No. 156.

[4] New York (Geneva) Exp. Sta. Bul. No. 459, pp. 45–69.

yield was 353.4 bushels as compared with 184.8 bushels for the unselected stock, overturning completely the 1919 result and bearing out the results of former years, namely, that the pedigreed strain was greatly superior to the unselected stock of the same variety when grown under the same conditions.

"The poor yields obtained from the "mixed" and " general" stocks show that remnants of even selected stock are not good for seed after the best hills or best strains are taken out.

"In the degenerate strains that formed part of the experiment until 1916 there was much disease, particularly Rhizoctonia. It is probable that there were present also the diseases of degeneration, such as curly dwarf, leaf-roll, spindling sprout, and mosaic studied by Stewart[5] in New York and reported by Whipple[6] in Montana. Degeneration, however, does not seem to be always due to disease, at least to any now recognized, for among the foliage selections is a strain (Mg 25–1–9–20–3–19) selected in 1917 for chlorosis to the extent of more than half the leaf-area. Another strain showed about one-fifth of the leaf-area to be chlorotic. These two strains have continued to breed true, the plants bearing leaves that are chlorotic to about the extent of one-half and one-fifth the leaf-areas, respectively. Other chlorotic selections failed to breed true. During 1920 M. Shapavolov, potato pathologist for the U. S. Department of Agriculture, kindly examined these strains for disease. He could not recognize any disease. Either there must be degeneration without disease, or some disease not yet segregated from the others. Possibly there may be a chlorotic condition other than mosaic, or hiding mosaic, that should take rank with curly dwarf and mosaic.

Summary.

"In 1911 high-yielding and low-yielding hills were selected from three potato varieties—Bangor, Peerless, and Majestic. These hills were planted in individual progeny rows and so harvested as to keep each hill separate. Similar selection was continued until 1914, when Bangor and Peerless stocks were discarded on account of inferiority in yield of both these varieties to Majestic. Good and poor selections were made from this variety until 1916, but thereafter until the present the only selections made were for high yield, with the exception of a few strains that developed unusual foliage characters.

"The experiment was so conducted as to avoid selection for somatic characters and to secure selection for gametic qualities. This was done by growing all of the best strains for two or more years in order to get a progeny test of the power of a strain to transmit its desirable qualities to the succeeding generations. In no important cases were selections made on the results of one season; usually three to five years were regarded as necessary to show whether a strain should be selected or discarded.

"By 1915 the high-yielding strains yielded an average of 301.03 bushels to the acre as compared with 179.30 bushels to the acre for unselected. From 1915 to 1920 the selected strain has out-yielded the unselected stock of the same variety by more than a hundred bushels an acre, except in 1919, when there

[5] New York (Geneva) Exp. Sta. Bul. No. 422, pp. 319–357.

[6] Montana Exp. Sta. Bul. No. 130, pp. 3–29.

was a difference of only 29.6 bushels. Possibly the extremely unfavorable growing season of 1919 may have caused this wide fluctuation. At any rate, the superiority of the selected strains manifested itself again in 1920, out-yielding the unselected strain by 168.6 bushels.

"Not only were the acre-yields of selected strains higher than those of unselected stock, but there were more tubers to the hill; the individual tubers were larger; and, as a consequence, there was a higher percentage of marketable potatoes than in the unselected stock.

"As a six-year average, 1915–1920, the acre-yield of the selected strain was 60.9 per cent greater than that of the unselected, and the average size of tuber 24.4 per cent greater than that of the unselected. Remnant hills and strains, after the best had been selected out for seed, gave somewhat poorer yields than did unselected stock.

"The germination of the selected strain is more rapid, the stand is better, the growth thriftier, and diseases less apparent than for the unselected potatoes of the same variety.

"A degenerate strain of highly chlorotic foliage has been isolated. A potato pathologist could recognize no known disease on the strain."

[J. A. V.]

Phosphoric Acid at Paauhau.

PAAUHAU EXPERIMENT NO. 12, 1919 AND 1921 CROP.

This was a test to determine the value of phosphoric acid on acid soils in Hamakua. The experiment has been carried on through two crops, one plant and one ratoon. The cane was Yellow Caledonia. Reverted phosphate was applied at the rate of 0, 750, and 1500 pounds per acre. It was placed in the furrow by hand before planting and well mixed with the soil.

Phosphate was applied to the plant crop only. The 1921 crop was fertilized entirely with nitrate of soda.

In addition to the reverted phosphate all plots received a uniform application of nitrate of soda, 1100 pounds for the first crop and 1000 for the second.

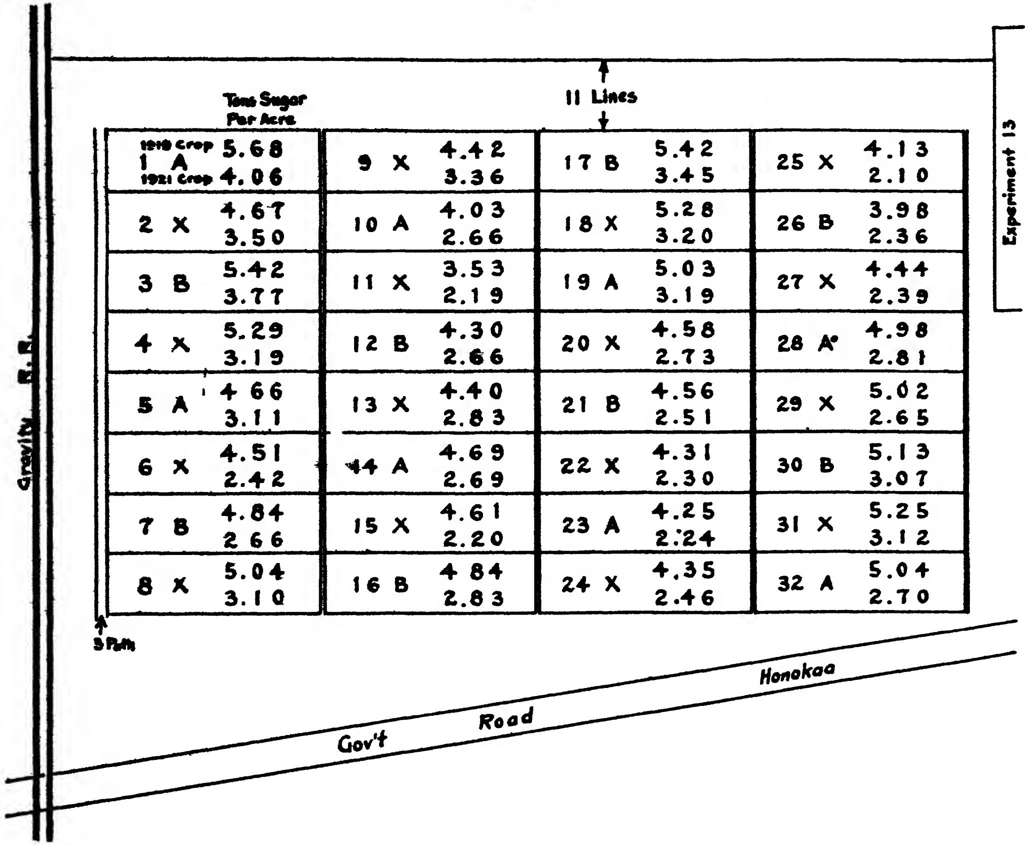
The results of the harvests are as follows:

Plots	Treatment	TONS PER ACRE			
		Cane		Sugar	
		1919	1921	1919	1921
X	No reverted phosphate..................	36.9	4.61	25.8	2.73
A	750 lbs. reverted phosphate............	38.8	4.79	27.8	2.93
B	1500 lbs. reverted phosphate............	38.7	4.81	27.4	2.91

Reverted Phosphate Experiment.

Paauhau Sugar Plantation Co. Exp. 12, 1919 & 1921 Crops

Field 3

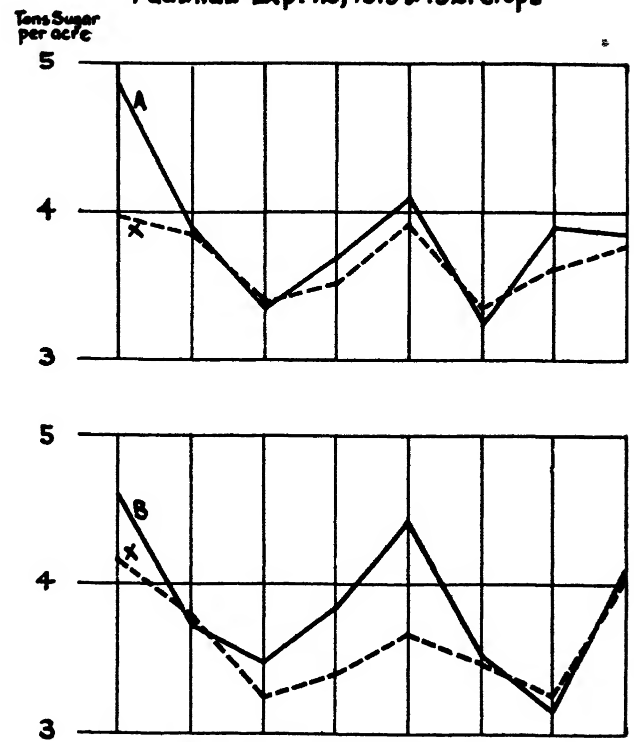


Tons Sugar Per Acre

Plot	1919 Crop	1921 Crop	Plot	1919 Crop	1921 Crop	Plot	1919 Crop	1921 Crop	Plot	1919 Crop	1921 Crop
1 A	5.68	4.06	9 X	4.42	3.36	17 B	5.42	3.45	25 X	4.13	2.10
2 X	4.67	3.50	10 A	4.03	2.66	18 X	5.28	3.20	26 B	3.98	2.36
3 B	5.42	3.77	11 X	3.53	2.19	19 A	5.03	3.19	27 X	4.44	2.39
4 X	5.29	3.19	12 B	4.30	2.66	20 X	4.58	2.73	28 A	4.98	2.81
5 A	4.66	3.11	13 X	4.40	2.83	21 B	4.56	2.51	29 X	5.02	2.65
6 X	4.51	2.42	14 A	4.69	2.69	22 X	4.31	2.30	30 B	5.13	3.07
7 B	4.84	2.66	15 X	4.61	2.20	23 A	4.25	2.24	31 X	5.25	3.12
8 X	5.04	3.10	16 B	4.84	2.83	24 X	4.35	2.46	32 A	5.04	2.70

Curves Comparing Average Yields For Two Crops, With & Without Phosphoric Acid.

Paauhau Exp. 12, 1919 & 1921 Crops



A plots 750# Reverted Phosphate per acre.
B plots 1500# Reverted Phosphate per acre.
X plots No Reverted Phosphate.
Phosphate applied to plant crop only.

The gains from the phosphate applications were the same for both crops and amounted to about two tons of cane and 0.2 ton of sugar per acre. This gain is small, but it is fairly consistent as shown by the curves of plot yields shown on page 31. That the phosphate needs of these soils are not very great is further shown by the fact that 750 pounds of reverted phosphate supplied all the P_2O_5 wanted for at least two crops (see table giving yields of A and B plots).

Under conditions such as the above all the phosphoric acid needed will be supplied by the mixed fertilizers now being used on the plantation.

This field is now being plowed and the experiment will be discontinued and replaced by one testing the value of potash.

DETAILS OF EXPERIMENT.

Object:

To determine the value of reverted phosphate on acid soils in the Hamakua district.

Location:

Paauhau Sugar Company, Field 3.

Crop:

Yellow Caledonia, plant and 1st ratoon.

Layout:

Thirty-two plots, each ¼ acre, consisting of 10 lines, 5 ft. wide and 217.8 ft. long.

Plan:

FERTILIZER—POUNDS PER ACRE.

Plots	No. of Plots	Treatment	
		1919 Crop	1921 Crop
X	16	No reverted phos.* and 1100 lbs. Nit. Soda......	1000 lbs. Nit. Soda
A	8	750 lbs. reverted phos. and 1100 lbs. Nit. Soda...	" " " "
B	8	1500 lbs. reverted phos. and 1100 lbs. Nit. Soda..	" " " "

* Reverted phosphate applied in furrow before planting and well mixed with soil.

In harvesting the cane was flumed into cars and weighed. Each car was sampled at the mill and the juices averaged for each treatment.

J. A. V.

The Selection of Rubber Trees According to Individual Differences in Yield.*

I—These are the results of a series of observations made in the Federated Malay States on the specific differences in the amount of rubber yielded by individual trees of *Hevea brasiliensis* of the same age and growing under the same conditions, in order to establish also whether there exists a correlation between

* International Review of the Science and Practice of Agriculture, Vol. XI, pp. 184–185. 1920.

the yield and the girth of the trunk. Some 1000 trees, 7 years old, in a normal plantation covering 13 acres, were carefully studied, the trees being in their third year of tapping.

Great variations were found in the rubber content of the latex (the "strength" of the latex) from different trees, and appeared to be constant from year to year. Some trees yielded 23 gm. of rubber per 100 c.c. of latex, others as much as 54 to 55 gm. per 100 c.c. of latex, the mean of the 245 trees examined being 39.58 gm. per 100 c.c.

The rubber content of the latex increases as the trees grow older, to the extent of ½ per cent per annum.

The author admits the possibility of obtaining good positive results from selection based entirely on individual variations; if high-yielding trees can be segregated and provided that pollen of poor-yielding trees can be prevented from gaining access to the flowers, it should be possible to get seeds capable of producing trees with a high percentage of rubber in the latex. There is a definite correlation between girth and yield, but it is not sufficiently well indicated to be of great value in eliminating trees from a plantation.

II—In Hevea plantations there are good and bad yielding trees. For 5000 trees 8–9 years old, the mean daily yield of latex was 22 c.c. Eighty per cent of these trees gave on the average ± 10 c.c., while the remaining 20% alone produced 65% of the entire yield. It is to be inferred from these results that productivity is a hereditary character.

On the other hand, in plantations, free cross-pollination mixes good and bad elements in the most varied of genetic combinations, while complete segregation of the best specimens involves very great difficulty from the technical and practical point of view.

The author urges the suitability of vegetative propagation of the best yielding trees, by grafting on to the young plants slips from specimens that have been under careful and continuous control and are notable for their high yielding properties.

It is a case of repeating with *Hevea brasiliensis* that which is being tried at present with coffee and cacao in Suriman and has already been carried out on a large scale in the United States citrus plantations. [W. W. G. M.]

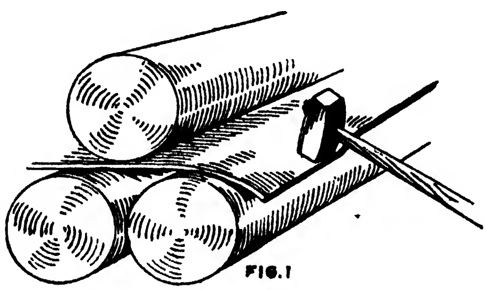
The Single-Sheet Lap-Seam Boiler.

By J. P. Morrison.*

It is probable that no question of machine design has received more careful and intelligent consideration than has the design of the shell seams of steam boilers. Fairbairn's tests were conducted in 1838. W. Bertram conducted tests at the Woolrich Dock Yards in 1860. D. K. Clark discussed riveted seams in 1877. A lap-seam crack was reported in *The Locomotive*, issued in April, 1880,

* Chief inspector, Hartford Steam Boiler Insurance and Inspection Company.

while that publication dealt at considerable length with the stresses occurring in lap seams. On April 17, 1891, J. M. Allen, who was then president of the Hartford Steam Boiler Inspection and Insurance Co., delivered a lecture at Sibley College, in which he gave a complete diagnosis of the various joints then in use, having particular reference to the triple-riveted butt-strap joint. This lecture was published and widely distributed, and the principles set forth are those upon which the calculations of riveted joints, encountered in modern practice, are based. In the early days of steel-plate manufacture the product was confined to sheets of small dimensions. As a consequence the boilers built in those days were composed of a number of courses, and each course, if the boiler was unusually large, would be made up of several sheets. It was not uncommon to encounter a boiler 14 ft. in length and 48 in. in diameter made up of seven courses formed of four sheets each. But as the steel makers became able to produce larger plates, boilers were constructed of a lesser number of courses, each composed of fewer sheets. This appeared to be of considerable advantage in many ways, and when it became possible to produce plates of such size that only two were needed to form the shell plates of a boiler, they found a ready market. With the development in steel manufacturing the importance of the physical and chemical properties of the boiler plates was recognized, particular emphasis being placed on the advantages of great ductility even when obtained at a loss in ultimate tensile strength. Laminations found in steel plate had elicited some criticism, and there was a loud protest at the practice of some steel makers of shipping unbranded plates, for the boiler makers were beginning to realize the necessity of having the steel maker's brand appear on each sheet of the finished boiler. Boiler plates manufactured by both the open-harth and bessemer processes were used, and it was understood that the quality of the boiler plate depended more upon the grade of raw materials than upon the particular procss.



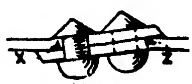


Fig. 1. Forming end of plate over roll.
Fig. 2. Ends of plate to be sledged to shape.
Fig. 3. Lap seam stressed to failure.

Difficulty that had been experienced by reason of girth-seam leakage, fire cracks and mud burns, all attributed to the sediment within the boiler accumulating against the girth-seam laps, gave added attraction to the idea of rolling one sheet to form the bottom half of the boiler. The upper half continued in some cases to be constructed of two or three plates, while in other cases one large plate only was used. This form of construction necessitated the use of a longitudinal seam on each side of the boiler extending from head to head, and was confined to shops having plate-bending rolls of sufficient length to pass a 16-ft. or 18-ft. sheet between housings.

It is worthy of note that this construction was criticized twenty-five or more

years ago, and subsequent developments have proved the correctness of those who, while without sufficient facts at hand to justify outright condemnation of the single-sheet boiler, brought its weaknesses to public attention and withheld approval, citing the explosion of one boiler due to the single bottom sheet construction, and which resulted in the loss of two lives and an estimated property damage of $5,000. Those unacquainted with shop practice of the older days will hardly realize the possible damage done to a sheet during the process of fabrication of the boiler. The rivet holes were punched full size, except where special requirements were to be met, so the mill cracks started by the punching process were not removed. Few of the shops were equipped with a press to shape the

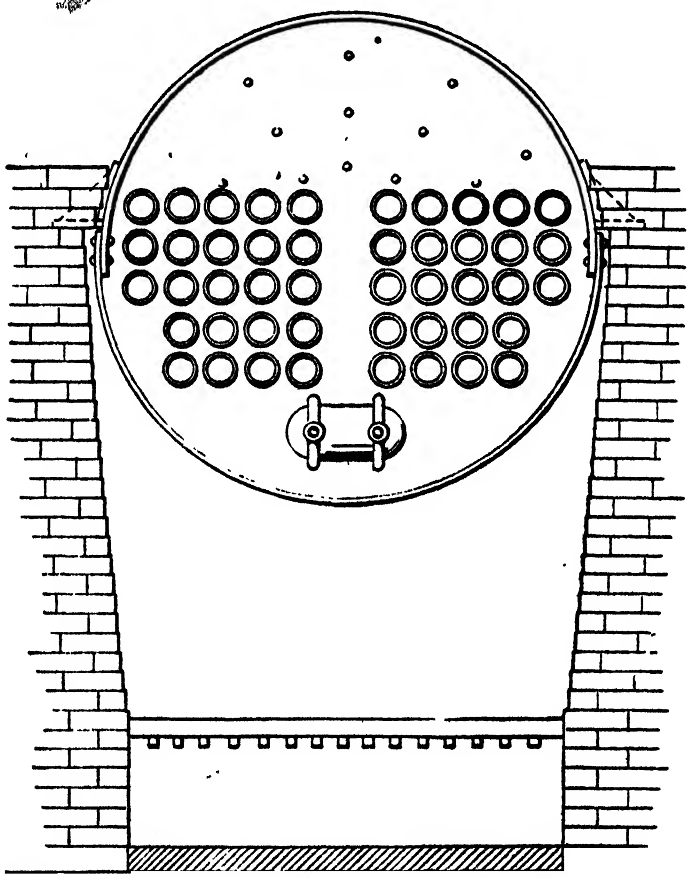


Fig. 4. Seams of single-sheet boiler inaccessible and exposed to furnace heat.

ends of the sheet to the proper curvature. The work was done by placing the sheet over a rail or one of the bending rolls and sledging the edges, often stressing the questionable material beyond its elastic limit along the line of rivet holes in the second row, where the sheet had already been weakened by the reduction of the metal and by mill cracks, due to punching the rivet holes. To this were added the stresses set up when the poorly fitting joint was bolted up and later riveted. Usually, the joint was then sledged into shape for calking.

Fig. 1 indicates the change in shape of the ends of a plate when being formed over the roll by the use of the sledge. Fig. 2 illustrates the condition of the ends

of the plate, after the rest of the plate has been rolled to the proper curvature. The ends, having been shaped by blows of the sledge, do not conform to the true curvature. That was also the era of the drift pin, when an unfair hole could be made fair, adding more stresses to the sheet along the line of rivet holes.

Even then the trend of the times was towards boilers of larger diameter. Since the size of the plates obtainable would not permit locating the head-to-head seams above the horizontal diameter, the seams of such a boiler were exposed to furnace temperatures, in addition to the stresses due to difference in temperature of the upper and the lower section of the boiler, the former being exposed to the atmosphere, while the latter was subjected to furnace head as indicated in Fig. 4. The intensity of these stresses would vary considerably, but one authority has reported them as amounting to approximately 6,000 lb. per square inch.

The never-ending effort of the contained pressure to perform the impossible feat of rounding out the irregular surface existing at the lap seams produces the lap-seam crack, for which this joint is notorious. In Fig. 3 x and z indicate the development of such a crack, while Fig. 5 shows a crack that developed in a plate in service. Furthermore, this lack of symmetry renders the plate along the line of greatest stresses susceptible to corrosive action, which would be intensified where there were three pairs of supporting brackets, as was the case with large boilers; and the settling of the furnace walls at the front or rear transferred the load, amounting to one-half the weight of the boiler and contents, onto the center bracket.

The strengthening effect of the girth seam has been the subject of considerable discussion. It is in principle quite the same as applying a hoop to the circumference of the boiler. This is evidenced in a number of instances when, upon the vessel being stressed beyond the elastic limit, the increase in circumference did not even extend to the girth seam, owing to the hoop effect of the seam. The fact that the explosion of a two- or three-course boiler, due to lap-seam failure, rarely results in a rupture extending across a girth seam should leave no need of further arguments in favor of a construction embodying girth seams.

Before the double-strapped butt joint was universally adopted, a large number of lap-seam boilers, many of them of the single-sheet variety, were placed in operation. The majority of these boilers were intended for 100 lb. pressure, using a factor of safety of 4. This factor has been generally recognized as inadequate, even for boilers of superior construction, and could not be expected to be continued as satisfactory for lap-seam boilers after a few years of service and abuse.

After considering the various factors having a direct influence on the safety of single-sheet boilers, it does not appear strange there have been so many violent explosions, with the loss of numerous lives and property damage approximating a million dollars in value. The facilities for investigating boiler explosions were probably not in keeping with the general industrial activities, but in the early days, when 80 to 100 lb. pressure was considered high, each explosion was more or less shrouded in mystery, and the theories advanced as to the cause were about as intricate and vague as could be imagined. The presence of a

super-gas, the spheroidal state of the water, the geyser action of the water, superheated water, low water or no water, inflammable steam and the presence of a vacuum were theories, each of which had its following. The cause of the difficulty, the single-sheet lap-seam crack, was generally overlooked by investigators seeking to establish the correctness of their pet theory as to the force, or phenomena causing the destruction. A few engineers realized the influence of manufacture on boiler safety. Zera Colburn is quoted as stating in 1880, "All our knowledge of boiler explosions goes to show that in the majority of cases the actual explosion results from some defect, either original or produced, and either visible or concealed, in the material, workmanship or construction of the boiler."

There is no complete list of explosions of single-sheet boilers nor of the number that have been found to be unsafe and discarded from service, but the record available is sufficient to indicate clearly the unusual hazard attending the operation of boilers of that description. The condemnation of a boiler having a seam crack 14 ft. in length was recorded in 1894, and on February 1, 1895, a boiler 66 in. in diameter by 16 ft. long, containing 54 four-inch tubes, and constructed of steel plates 3/8 in. thick, forming a single course of the bottom of the boiler and three courses of the top, exploded in an electric light plant with disastrous results. One man is reported to have been killed, three others seriously injured, and the power plant totally wrecked. The line of failure followed the seam from the head two-thirds of the length of the boiler, from which point separation occurred, the girth seam being followed across the top

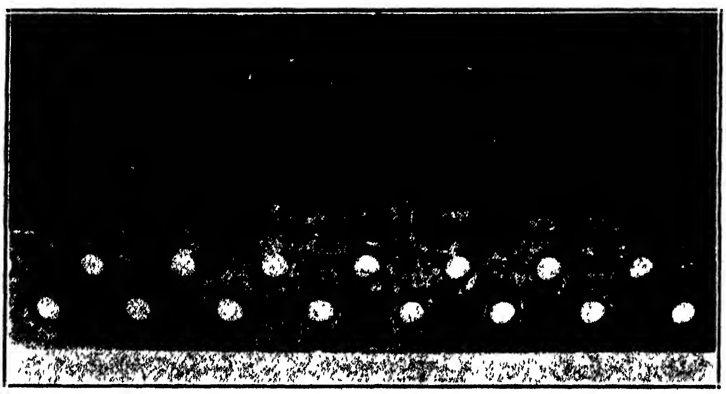


Fig. 5. A lap-joint crack.

of the boiler by one branch of the crack, and the other extending through the solid plate downward toward the rear. The boiler had three pairs of supporting lugs, and conditions indicated that the initial failure occurred under the middle lug.

The Rochester, N. Y., Brewery explosion followed in 1899, and caused the death of one man, as well as property damage estimated at $25,000. On November 26, 1901, a disastrous explosion of a 66-in. by 16-ft. boiler at the plant of the Penberthy Injector Works, Detroit, Mich., demolished a three-story brick building and cost the lives of thirty and seriously injured thirty-five others.

The total property damage was estimated at $100,000. This boiler had seen but six or seven years of service and was understood to be in good condition. The line of failure followed the longitudinal seam on one side of the shell, substantially in a straight line from one head to the other.

Of a single-sheet boiler the next violent explosion of which record is available, occurred at the plant of the American Tin Plate Co., Canton, Ohio, on May 11, 1910, and was reviewed in the issue of *Power* of May 31 of that year. Then followed the Midvale, Ohio, explosion and the Shelton, Conn., explosion in 1911; the Pleasant Valley, Conn., explosion in 1915; the Athol, Md., explosion in 1916, and the Cross Run, Pa., explosion in 1917; all bearing the earmarks of lap-seam defects and occurring to single-sheet boilers, taking the usual toll in life and damaged property.

While the Fargo, Tex., explosion, occurring on October 1, 1914, was caused by a lap-joint failure of a single-sheet boiler, it differed materially from some of those previously mentioned, inasmuch as the boiler had been carefully ex-

Fig. 6. Result from the explosion of a single-sheet boiler.

amined by an expert inspector and pronounced unsafe to operate, his opinion being based on the corrosion which had attacked the longitudinal seam. These seams were not visible on account of their location below the upper tubes, but after cleaning those parts as thoroughly as possible, the inspector determined by his finger tips that there had been so much reduction in thickness that there was not sufficient strength to withstand the pressure. However, the owner placed the boiler in operation and the second day thereafter it exploded, killing two men, injuring two others and wrecking the plant. Investigation developed the fact that the rupture had occurred in the outer sheet of the lap, that sheet forming the bottom half of the boiler, as is common with single-sheet construction, and followed a line parallel to the edge of the inner lap, extending from head to head through metal which, owing to corrosion, did not average ⅛ in. in thickness.

The accompanying photographs, Figs. 6 to 8, illustrate the damage done by the explosion of a single-sheet boiler, which resulted in the death of two work-

men, the serious injury of two others, and the total destruction of the plant. Fig. 6 gives a good idea of the general damage to the plant, and Fig. 7 is a close-up view of the boiler tubes and head. The boiler was said to have been 24 years old, and its builder was unknown, as it had been used elsewhere and had changed owners a number of times. So far as could be learned, the boiler had never been subjected to an examination by anyone qualified to pass judgment in such matters. The double-riveted lap seams extended from the front head to the rear head on each side of the boiler. The means of support consisted of three pairs of cast-iron brackets resting on the furnace walls, one being between the dome and longitudinal seams, on either side of the boiler. The pressure carried at the time of the explosion was 100 lb., and it was probable the builder sold the boiler when new with the customary guarantee of that pressure, which would be permitted by a factor of safety of 4.

Some time previous to the accident leakage was observed at the longitudinal seam under one of the center support brackets. A boilermaker of questionable ability and experience patched the seam as indicated by the arrow in

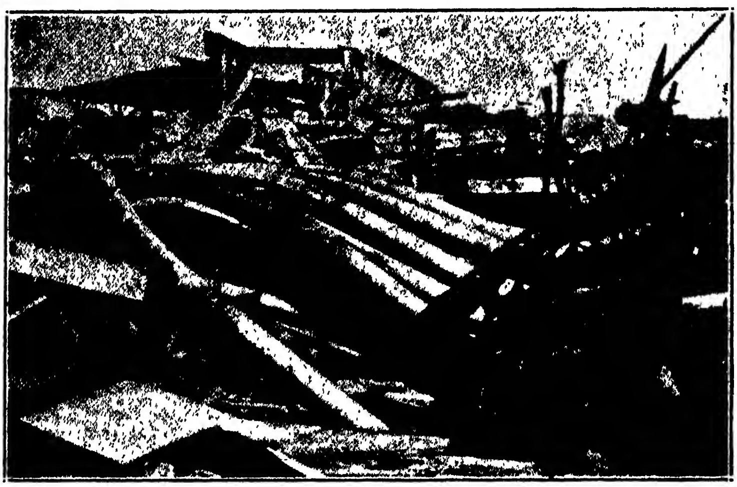


Fig. 7. Close-up view of boiler tubes and head.

Fig. 8, apparently without giving thought to the cause of the difficulty, but riveting the patch at the boiler seam and using patch bolts for securing the new seam. The boiler was continued in operation without further trouble until about a week before the explosion, when seam leakage was again observed. The mill superintendent and an employee are said to have drilled and threaded for ¾-in. capscrews, four holes along the seam where leakage had appeared. A soft patch consisting of a sheet of plow steel and a thin sheet of lead was secured to the boiler by means of capscrews and nuts, and the boiler was again placed in service.

The failure occurred in the sheet forming the lower part of the boiler, on a line coinciding with the edge of the inner lap, just about the same location as in the failure of the Fargo, Tex., boiler, and did not follow nor enter the rivet holes. It extended the entire length of the seam, as is customary with violent failure of this kind. The rivets in the head seams either sheared at the junction

of the plates or the rivet heads pulled off, as none of the rivet holes were destroyed, although some of them were found to be considerably elongated.

After an accident, where there are so many possible causes, it is difficult to define responsibility. In this case the center bracket above the point where the initial leakage and crack developed, most likely supported the entire weight of that side of the boiler, which, as has been outlined, would follow from the settling of the furnace at the front or back bracket, and would clearly justify the modern requirements which provide for four-point suspension only. The factor of safety was not one-half as great as considered necessary by good authorities for boilers of such great age and design, and had a proper factor of safety been maintained, the explosion would not have occurred, as the pressure permitted then would not have been sufficient to operate the plant, and the boiler would have been scrapped.

Had the service of the boiler been limited to ten years, as has been advocated for the lap-seam boiler, its use would have been abandoned years before.

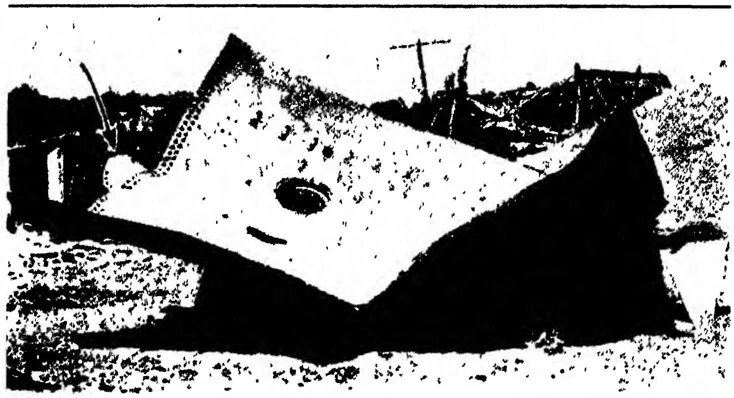


Fig. 8. Shell plates blown free of the ends and tubes.

The owner no doubt would have experienced some financial loss, but nothing compared to the loss resulting from the explosion. Had the boilermaker who patched the boiler been acquainted with developments of recent years, so far as boiler design and safety are concerned, and the rules which prohibit repairing a boiler in which a lap-seam crack has developed, or had the mill superintendent realized the clear danger warnings and discontinued the boiler from service until the advice of competent persons could be obtained, there would have been no explosion. This accident emphasizes the difficulty of obtaining proper co-operation of boiler owners in enforcing reasonable rules and regulations, as the boiler was being operated without a certificate from the state authorities, who had no knowledge of its existence, and it is doubtful if the owner and those in charge of its operation knew that the boiler differed in any material way from new boilers of modern design.

Fortunately, the installation of new boilers of this description is prohibited in many states and cities, so its manufacture practically has been abandoned, but there are a great number in operation, and the next few years may witness an increasing number of failures, as the defects, undoubtedly existing, develop until

rupture takes place. An increase in the factor of safety will result in a reduction of pressure; this may cause the removal of the boiler from its present place of operation, to be disposed of, if there are no restrictions, through dealers in second-hand boilers, only to be placed again in service, to the jeopardy of someone's life and property.

In discussing the Cross Run, Pa., explosion, *The Locomotive*, in the July, 1917, issue, asserts: "The lap-seam boiler has been a fruitful source of steam-boiler accidents in this country, and of lap-seam boilers perhaps no class has been more subject to disaster than those made in a single course with two sheets, one above and one below." It is evident that the single-sheet boiler "has been weighed in the balance and found wanting." It has sustained injuries during the process of fabrication, is impossible of thorough inspection, has been stressed beyond its safe limit by temperature difference, by continual flexture due to non-conformity to a true circle, by lack of girth-seam support, and by the unequal distribution of the weight of the boiler, contents and connections.

Shall those boilers now in use be continued in service, to change owners and operating conditions at will, until each gives positive and direct evidence of its worthlessness by exploding, with the aggregate loss of another hundred of lives, and of another million-dollar property damage? Or shall the rule against habitual criminals be invoked, and each boiler of that type sentenced permanently to the scrap yard, where it will have no further opportunity to destroy, just as the police character, in whom the bad outweighs the good, is given an indeterminate prison sentence, so he can do no more injury to society? If those financially responsible for the continued operation of single-sheet boilers could be made to realize that immediately preceding each lap-seam boiler accident the owner considered his boiler perfectly safe to operate; or appreciated the fact that under certain circumstances any person might be the victim, as our sidewalk basement boiler rooms, hotel power plants and department store power plants, if they do not contain unquestionably safe equipment, place the lives of all in jeopardy; or realized that defective boilers endanger the lives of the employees to whom the employer owes the moral responsibility of furnishing safe tools—then there is no question that the verdict would be, "The single-sheet boiler must go." [W. E. S.]

The Position of the Seeds in the Soil at the Time of Sowing.*

I—Results of experiments comparing the method of planting sugar cane setts of one eye-bud placed upwards with other improved methods, especially with the method of setts of three eye-buds pointed sideways.

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* International Review of the Science and Practice of Agriculture, Vol. XI, pp. 332–333. 1920. (Experiments in India.)

Owing to special conditions of soil and water the Brix reading of the juice scarcely exceeded 14% in the different methods of cultivation. Hence the table given below (which compared the results given respectively by: (A) Setts of one eye-bud pointed upwards; (B) setts of three eye-buds pointed sideways) indicates only the yield in cane and not the yield of "gur" (crude sugar).

RESULTS OF COMPARATIVE EXPERIMENTS OF PLANTATION.

Method of planting	Number of eyes planted	No. of plants germinated after 20 days of planting	Percentage of germination	No. of plants finally kept (mother and tiller plants)	Number of canes harvested	Weight of canes harvested	Average weight of one cane
I.—Plot of 1 "guntha" (1/40th of an acre):						lbs.	lbs.
(A) Single eye-bud, point upwards	901	833	82	1079	843	4325	——
(B) Three eye-buds points sideways	1002	511	50	889	782	3366	——
II.—Plot of 30 "gunthas" (¾ of an acre):							
(A) Single eye-bud point upwards	27030	24990	82	32370	25290	129750	5.1
(B) Three eye-buds points sideways	30060	15330	50	26670	23460	100980	4.3

The Brix reading being only 14.2% in both methods of planting, the yield in "gur" obtained for 30 *gunthas* was:

(A) Single eye-bud, point upwards .... 12,570 lbs.
(B) Three eye-buds, points sideways .... 9,660 "

If the Brix reading had been 18 to 19%, as is usually the case for sugar cane, the yield in "gur" would have been:

(A) Single eye-bud, point upwards .... 16,350 lbs.
(B) Three eye-buds, points sideways .... 12,725 "

These figures show that the yield of cane was about 25% higher with method (A) than with method (B). Further experiments on a larger scale are being carried out on the Canal Farm at Gokak.

There are, however, certain disadvantages in the method of planting single eye-buds, point upwards. The setts being too small and exposed on both sides close to the bud, the plants developed from them, though they take more quickly than those developed from setts with three eye-buds, points sideways, look somewhat unhealthy during the first month until a small dose of ammonium sulphate is given as a top-dressing; but after that top-dressing the plants (A) grow as luxuriantly as plants (B).

The following year a fresh experiment was made: Setts with three eye-buds were taken and the middle eye-bud was removed; the sett was then planted with the two remaining eye-buds upwards. It is expected in this way to obtain

a better yield than with the single eye-bud point upwards method of the previous year, owing to the elimination of the defects of the single eye-bud method while retaining the advantage of position of the eyebuds point upwards.

II—In view of these results, the author investigated the effect which the position of the seed in the soil at the time of sowing might have on the yield of various plants.

Experiments with maize, leguminous plants and cotton showed that when the seed is planted with the point downwards or sideways, the resulting plants are better than when the seed is planted point upwards.

The position of the seed in the soil at the time of sowing is one of the numerous causes of the unevenness in plants and crops, and even of the non-germination of good seed. But in practice it is only possible to plant the seeds in the proper position when planting is done by hand.

[W. W. G. M.]

Power Cultivation of Sugar Cane.*

By Arthur H. Rosenfeld.

In the report of the Committee on Agricultural Machinery and Implements of the Hawaiian Sugar Planters' Association for the year ended September 30th, 1919, we find the following remarks in a letter to Mr. Lidgate, the Chairman of the Committee, from Mr. David Forbes, the manager of the Waiakea Mill Co., in regard to the possibilities of motor cultivation of cane:

"It is the writer's belief that at no distant date tractors will be on the market of lighter build adapted to such work as cultivation of cane rows and destruction of weeds, or in fact any sort of work where a mule, or mules, can now be used for cane cultivation. It takes no great stretch of imagination to look forward to such machinery and implements of agriculture being used more extensively and propelled by home-made fuel produced from our waste molasses."

The writer of these lines can assure Mr. Forbes that such mental anticipations indeed needed no great stretch of imagination, since, when that letter was written, he had already carried to a successful conclusion the preliminary experiments which led to a complete realization of all of Mr. Forbes' predictions and the adoption of light tractors propelled by alcohol made from our waste molasses in the regular routine of our cultural operations.

The use of heavy and even of light tractors for the preparation of the soil, working of roads, hauling, etc., has been too clearly and definitely demonstrated all over the world to be a success to warrant a discussion in these pages, but the author at least has been unable to encounter records of successful and eco-

* From The International Sugar Journal, Vol. XXII, No. 261.

nomical *cultivation* between the cane rows with tractors as the motive force.

Many light tractors have been on the market for years—the Fiat, Fordson, International, Titan, Avery, Cletrac, and Bates among a host of others—but little attention seems to have been given to the development of machinery to be drawn behind the "steel mules" in the actual routine cultivation operations of a cane field.

The writer has had this problem in mind for several years—in fact when the huge plantations of Santa Ana and Lules were entirely renovated in 1916 and 1917 with new verieties of cane under his direction, the rows in the fields were all laid out in as continuous straight lines as possible and the headlands and irrigation and drainage ditches arranged with the view of interfering just as little as possible with long pulls and few turns. Probably few cultivation

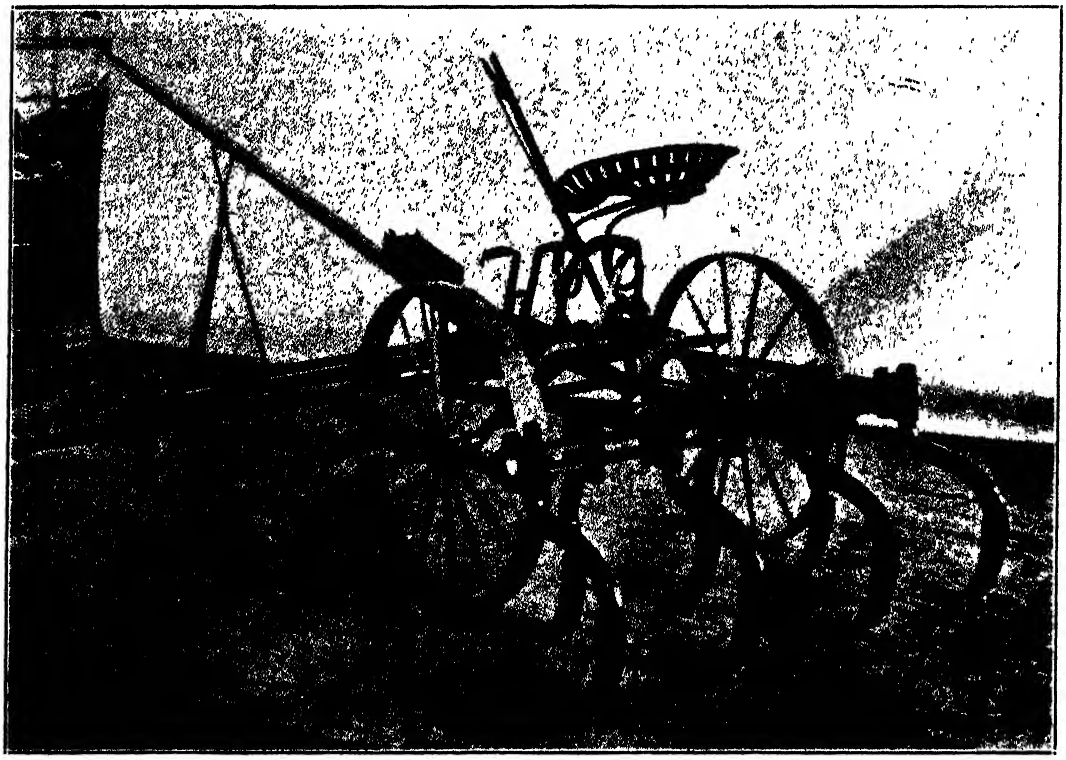
Some of the Motors with various Implements.

managers realize the enormous waste of time and the great amount of wear and tear on the machinery incident to the cultivation of short rows even with mules or bulls, and this loss is all the more accentuated in motor cultivation. The object of the writer has been to so design his plantations as to avoid turns more than every half-mile or so, and this arrangement has contributed in no small degree to the financial success of our tractor trials.

The lack of available machinery for sugar cane cultivation with tractors was the most serious drawback to making the trials, which were not begun until we had definitely proved the feasibility of running on alcohol, since the cost of imported motor spirit or kerosene is prohibitive and the use of a combustible made from a waste product of the industry is a decided stimulus to the use of motors in cane cultivation. It may be mentioned here that denatured alcohol, made on the place and denatured under fiscal supervision, costs us about 8d. per gallon placed in the fuel tanks of the motors, as compared with about four times that cost for kerosene and more yet for naphtha or gasoline.

All the machinery used had to be made here at the factory or adapted from other tools in use on the place, some of the resultant implements being a combination of three or four distinct tools of various makes. Descriptions of these will be given further on and an idea of the construction of some of them can be obtained from the accompanying plates.

We selected the Fordson tractor for these trials, and, as a result of these, have definitely adopted it because of its cheapness, lightness, simplicity and ease of securing spare parts—these considerations after the discovery that the motor works perfectly on denatured alcohol, even though the agents themselves were somewhat skeptical on this point when we began the experiments. They feared



The Planet No. 43 Machine from which was made the Furrower or "Middle Buster."

that the earliness and dryness of the alcohol explosion would cause deterioration in the cylinders, but a year's work under all sorts of conditions has failed to reveal any sign of such an effect in any of the six tractors we have in use at present.

The carburetors of these motors needed no change for alcohol, the motor being started on gasoline and the little pre-heating coil serving to put the alcohol in satisfactory condition for easy explosion in about two or three minutes. Naturally, with alcohol, less carbon is accumulated on the sparking plugs than with kerosene. It is advisable to run the last four or five minutes at night on gasoline, so as not to leave alcohol, which contains water, in the carburetor until work is renewed, as rusting of the pre-heating coil may be the result.

Breaking Out Middles—The usual manner of breaking out middles is to

run two furrows down the center with ordinary 8-in. or 9-in. share plows. The author's desire was to break out the middles with one operation, and the first trials were made with a 14-in. furrower with a man behind. This immediately proved impracticable, as no man could keep up with the plow all day with the motor developing efficient speed. We then adapted a furrower to a Planet No. 43 cultivator body, and also to the Avery-Magnolia cultivator body, arranging the raising and lowering devices so that they worked satisfactorily with the double moldboard plows, thus converting our furrowers into riding

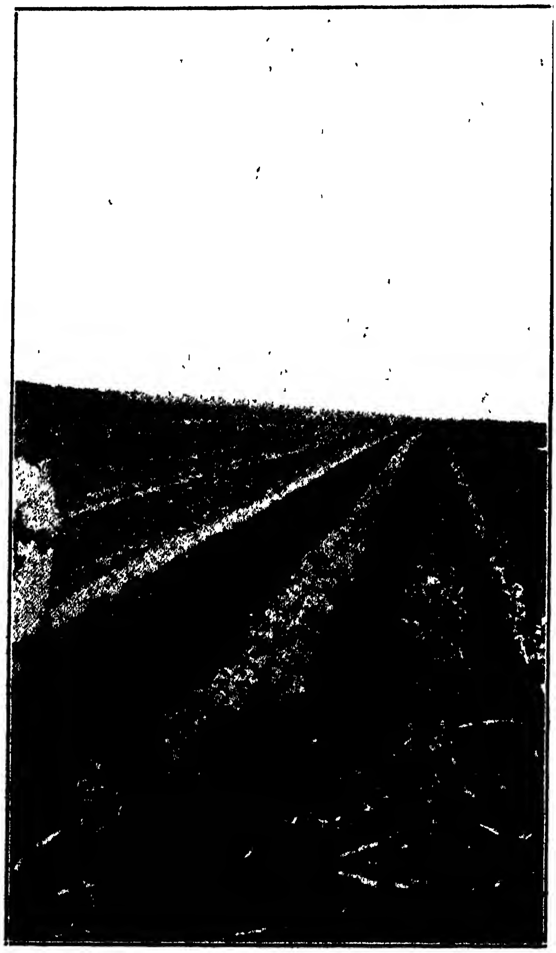
Off-barring Cane with a Tractor.

plows, until we can obtain a plow coupled direct to the tractor which will need no plowman for its attention, thus economizing one man's salary on the day's work.

The next difficulty with this implement was that it threw too much dirt to the rows and destroyed traction and depth of entry for the off-barring machine which followed it. This difficulty was finally met by removing the "wings" of the shares, when we found that we obtained just as good work without so much movement of the dirt to the rows.

With the furrower in its present shape, we can break out the middles of about ten acres of cane daily.

Off-Barring—For this work we utilized and strengthened the Deere disc-bedder, as shown in the illustrations. This work is usually accomplished by running a furrow close up to each side of the row with a share plow, but with this machine we do the work far better in one operation. This is really the prettiest work we have done with the tractors, the photograph evidencing its efficiency. The rows are smoothly and deeply off-barred, any projecting stubble cleanly pruned off and the dirt beautifully pulverized and thrown well to the



Cane Off-barred with Tractors. These Machines worked a half-mile without turning.

centers, leaving ideal conditions for the stubble shaver, which requires neat off-barring and the dirt well thrown away from the rows for full efficiency.

With this off-barring machine we cover eleven to twelve acres daily.

Shaving and Digging Stubble—For this work we combined the Avery stubble shaver and the stubble digger into one machine by taking off one pair of wheels of the shaver and connecting the two by a rigid plate. This is the quickest work which we do with the tractors and it saves the expensive spade or hoe

work of knocking the dirt off and from around the stools and returning the same dirt afterwards. It leaves the stools cut cleanly off and well down into healthy cane, lowers the rows for easier irrigation and subsequent cultivation and leaves an ideally soft mulch over the tops of the stubbles, conducive to quick and easy germination. The whole secret of success with this machine, which so many people seem to have ignored, is the keeping of the horizontal discs well sharpened and properly adjusted. We send a Little Luther grinder into the field with each machine and the discs can thus be easily and quickly removed and filed in about ten minutes after about two acres of work. By having extra discs with each machine, the only time lost is that required to unscrew and screw

The Disc Bedder arranged for off-barring with Tractors.

up again a couple of nuts for removing and replacing the discs, the discs taken out being sharpened by a boy while the machine is running, or after working hours at midday and evening by the tractor operator himself, for a few cents per disc.

With this machine fifteen acres of cane can be covered in a day, with rows at 6 ft. 6 in., as we have them here at Tucuman for the rapidly suckering Java canes. Naturally with 5 ft. rows, such as are commonly employed in Louisiana, Hawaii and many other countries, a proportionately smaller acreage must be calculated.

Miscellaneous Work—We have used the tractors, also, for throwing dirt to the cane by running the disc bedders down the centers, and for weeding by pulling a pair of reversible disc harrows, parallel and in two middles when the cane is still low enough for the motor to straddle the row, and tandem and in

Cutting and Shaving Stubble at One Operation.

one middle at a later time. For pulling ordinary road machines of the "Champion" type, they serve admirably, as well as for large plank drags, clod-breaking rollers, smoothing rollers and the like. In the coming cultivation season we expect to try them out for other operations of later cultivation.

Running Expenses—We have found it the best policy to have one good man in charge of all motors and give him good transportation facilities, such as a motor cycle or light motor car, thus enabling him, even on a very large place, to see all of the machines several times per day. The driving can be done by boys quickly broken into the work. These can start the motors and manage them, change sparking plugs, tremblers, etc., and see to the requisite supplies of water, oil, gasoline for starting and finishing, and alcohol, but any major trouble must await the coming of the man in charge. Such boys can be selected on any plantation from the brightest, more ambitious workers, and their salaries need be but little higher than the ordinary plowman's. Almost any boy would prefer to sit and drive a motor than to walk behind a pair of mules or bullocks.

Prices of materials vary so much in distinct countries that the author will not here attempt to calculate the cost of the work, which can easily be done by anyone interested by inserting the cost of alcohol, lubricating oil, etc., in his particular locality in the following table of daily consumption per tractor. These figures are for a day of eight hours' actual work, and include allowances for going to and coming from work at an average distance of three-quarters of a mile from where the motors are kept, the estimated quantities of materials used being, therefore, well on the liberal side. The amount of work done will be found under each operation already discussed—in number of acres covered per day.

DAILY FUEL AND OIL CONSUMPTION.

Denatured alcohol	80 litres	**Cylinder oil**	4 litres
Gasoline or naphtha	0.5 "	**Marine oil**	0.1 "

[J. A. V.]

The Loss of Fertilizers From the Soil.*

Professor J. Hendrick, B.Sc., of the University of Aberdeen, in a paper on "An Improved Scheme for Determining Unexhausted Manurial Values," which appeared in the Transactions of the Highland and Agricultural Society of Scotland, discusses the factors which influence the permanence of artificial and other fertilizers in the soil, with a view to the more accurate computation of the enhanced value of well-farmed lands. The following notes are abstracted from that portion of his paper dealing with the direct residues of fertilizers.

Nitrogen Compounds.

The case of nitrogen is the most difficult and complex, since it is removed from the soil *(a)* by crops, *(b)* by the drainage, *(c)* by escape into the air as gas through the decomposition of nitrogenous materials.

All the quick-acting nitrogenous manures are readily removed from the soil, and if not taken up by the crop are practically all lost from the soil by other means in the first year. They therefore leave no direct residue in the soil after the season of application. Nitrogenous manures which leave no direct residue after the first season are nitrate of soda, nitrate of lime, sulphate of ammonia, and nitrolim, together with the ammoniacal part of the dung and liquid manure of the farm. With these we may class dried blood and the nitrogenous part of Peruvian guano. Even in the case of manures made from the flesh of animals, such as meat-meal and the part of fish-guano which is not composed of bone, there is probably little residue left in the soil after the first season, and none after the second season.

On the other hand, slowly decomposing nitrogenous matters, like bone, hair, horn, and hoof, and the insoluble part of farmyard manure, which consists largely of straw, are only exhausted from the soil over a period of years.

Phosphate Manures.

The case of phosphates is quite different from that of nitrogen. Practically no phosphate is lost in the drainage, and it does not escape as a gas. Even when applied as soluble phosphate it is all retained by the surface soil. The only phosphate, therefore, which the soil loses is that removed by the crops. In the case of average crops of cereals, hay, and turnips, about 20 pounds of phosphoric acid, equal to about 44 pounds of tribasic phosphate of lime, is removed per acre per annum. This is equal to about as much phosphate as is contained in 1 cwt. of high-grade superphosphate, 38 per cent soluble phosphate, or in 1 cwt. basic slag, 40 per cent total phosphate. The equivalent of these, therefore, is removed from the soil per acre per annum by an ordinary crop.

Further, when soluble phosphate is applied to the soil it is quickly turned

* From "The American Fertilizer," Vol. 54, No. 10, in turn reprinted from "The Chemical Trade Journal and Trade Engineer," London.

into a state insoluble in water, but, like the greater part of the phosphate in basic slag or steamed bone-flour, remains soluble in dilute citric acid. This is what is usually referred to as "citric soluble phosphate."

It is sometimes held that "soluble" phosphate which has been applied to the soil gradually reverts to a state of still greater insolubility than is represented by "citric soluble phosphate," and so becomes gradually less available to plants, till in time it becomes almost worthless. There is no proof that this is the case. Such evidence as we possess is all the other way, and indicates that even after several years practically the whole of the soluble phosphate which has been applied to the soil, and has not been removed by crops, can be recovered from the soil as citric soluble phosphate. When, therefore, a soluble phosphate, such as superphosphate, has been applied to the soil, any residue which it may have left should be valued at the cost of citric soluble phosphate, such as that in basic slag or steamed bone-flour, and not at the cost of water soluble phosphate.

In order to test how far phosphates and other manurial substances are lost from the soil when large quantities are supplied in soluble form, drainage experiments were made in tanks filled with soil from Craibstone, the experimental farm of the North of Scotland College of Agriculture. The soil is composed of partially weathered glacial detritus, and is free working and open in texture. The tanks were four in number, each 20 inches deep. They were protected from rain, and the water applied to them was distilled water, which was sprayed upon them in carefully measured quantity. Tank No. I was unmanured. No. II received sulphate of ammonia at the rate of 45 cwt. per acre. No. III received sulphate of ammonia at the rate of 40 cwt. per acre, and superphosphate (30 per cent soluble) at the rate of 90 cwt. per acre. No IV received sulphate of ammonia at the rate of 40 cwt. per acre, superphosphate at the rate of 80 cwt. per acre, and muriate of potash at the rate of 45 cwt. per acre.

The manures were not all supplied at once, but were mixed into surface soil in increasing quantities at intervals of a few months. The total amount of water sprayed upon the surface of the tanks during the period of the experiments, which lasted two years, was equal to a rainfall of about 115 inches, and of this there was recovered as drainage from each tank about 93 inches. The remainder was lost by evaporation. The surface soil was stirred up to a depth of two or three inches from time to time, to prevent it becoming consolidated by the water which was sprinkled upon it.

The following table gives a summary of the results of these experiments:

CRAIBSTONE DRAINAGE EXPERIMENT.

Drainage Tank	I.	II.	III.	IV.
Manuring	Nothing	Sulphate of Ammonia	Sulphate of Ammonia Super-phosphate	Sulphate of Ammonia Super-phosphate Muriate of Potash
Nitrogen applied as ammonia....	0	1,068¼	949¾	949¾
Nitrogen in drainage as nitrate.	449½	1,611½	1,472	1,556
Phosphoric acid applied........	0	0	1,512½	1,352¼
Phosphoric acid in drainage....	4½	3½	3	3¾
Potash applied	0	0	0	2,447¾
Potash in drainage.............	44½	66½	74¾	1,163
Lime applied	0	0	2,868	2,572
Lime in drainage...............	981	3,857	5,388½	5,882½

The figures given in the table show that when nitrogen was applied as sulphate of ammonia to Tanks II, III, and IV in the excessive quantities used in these experiments, it was all recovered in the drainage in the form of nitrate. Practically no ammonia was washed through, even when in the last stage of the experiments sulphate of ammonia was applied in a single dressing at the rate of 20 cwt. per acre to each tank. Though the soil was acid in reaction and had already lost a very large quantity of lime, nitrification was practically complete; and while the ammonia was retained by the soil and appeared in the drainage only in traces, in a short time it underwent a complete change into nitrate, and was washed out in the drainage in that form.

Potash Fertilizers.

The case of potash is somewhat similar to that of phosphates, but is rather more complicated. While practically no phosphate is lost in the drainage, the loss of potash is quite appreciable, and varies considerably with the conditions.

At Rothamsted the annual loss of potash from the surface soil through drainage is stated by Hall to be 10 pounds per acre. At Craibstone three drain gauges, each 1/1000 acre in area, have been built. In 1919 complete records of the drainage and drainage losses were obtained with these for the first time. The soil was unmanured, but grew a crop of oats. The rainfall was 34¾ inches, and the drainage about 25 inches. The loss of potash in the drainage was at the rate of about 22 pounds per acre.

In the drainage experiment summarized in the table, one of the tanks was manured with heavy dressings of muriate of potash, which amounted in the aggregate to 45 cwt. per acre, and great quantities of potash were lost in the drainage from this tank. Tangs I, II, and III received no potash manure, and the amount of potash washed out of them was comparatively small, though the soil is naturally rich in potash. The amount of potash in the drainage of these tanks is small, but it is very much greater than the amount of phosphoric acid washed out of the same tanks; and it increases in amount in Tanks II and III, to which manures were applied.

The case of potash, therefore, is quite different from that of phosphate, which was completely fixed in the soil, even when applied to Tank IV in the heavy dressing just stated. It also differs from the case of ammonia, for the ammonia does not appear as such in the drainage, even under these abnormal conditions, but undergoes almost complete nitrification, and is washed out as nitrate. No doubt the formation of large amounts of nitric acid helped to remove the potash from Tank IV. We may conclude, then, that a certain amount of potash will be washed from the soil in drainage, in addition to that which is removed by crops. The amount so removed will vary considerably according to the conditions; and though the conditions of Tank IV are not likely to be equalled in practice, potash will probably be more readily lost from sour soils, badly supplied with available lime, than from others. It is probable, too, that the loss will be greater in wet climates, where much drainage passes through the soil, than in climates where the amount of drainage passing through the soil is smaller, though the evidence on this point is slight, and direct drainage experiments in wet climates are needed.

The above considerations indicate in general that where ordinary dressings of soluble potash manures—such as kainit, muriate of potash, potash manure salts, and sulphate of potash—are used, or where potash is applied in customary quantities in the form of mixed manures like turnip manures, potato manures, or grain manures, most of the potash is removed by the crop or lost in the drainage in the first season, and little unexhausted residue is left.

Lime.

The results of various experiments, and especially of drainage experiments, show that the available lime of the soil is lost mainly in the drainage, and that any loss which takes place through the removal of crops is trifling in comparison with the drainage loss. It has also been demonstrated that the nature of the manuring has an important bearing on the loss of lime. The use of sulphate of ammonia, soluble phosphates, and soluble potash manures increases the wastage of available lime; while, on the other hand, nitrate of soda diminishes this wastage; and nitrate of lime, nitrolin (cyanamid), basic slag, bones, and ground-mineral phosphates add some available lime to the soil, and so help to compensate for the wastage.

The period which elapses before a dressing of lime is exhausted from the soil depends mainly upon the quantity of lime used. This is well illustrated in the Rothamsted and Woburn experiments, which supply the best available data on the subject. The famous Broadbalk field at Rothamsted supplies a classical example of the long period which is required for the exhaustion of a very heavy dressing of lime. The continuous wheat and barley experiments at Woburn, on the other hand, supply valuable evidence of the rate of exhaustion of smaller dressings. It is very desirable that drainage experiments should be made under different conditions of soil, climate, and manuring, in order to obtain direct and accurate information as to the actual losses of lime from the soil. At present we are forced to draw conclusions from very scanty and somewhat abnormal data which do not represent more than a small portion of the

conditions which actually occur in practice. Such information as we have, however, shows that practically all the loss of lime from the soil takes place through drainage. Any loss which occurs through the removal of crops is in comparison trifling. The drainage loss exhausts the lime of the soil continuously, whether a crop is grown or not, and whether the soil is manured or not. Even in the case of unmanured and unlimed soil there is a considerable loss of lime, which increases to some extent with the amount of rainfall and drainage, and with the amount of available lime in the soil. When the land is intensively farmed and manures are added, the loss of lime is increased, especially when ammonia compounds are used. Probably the loss of lime is increased by the use of farmyard manure also, but there is little evidence on this point. [J. A. V.]

SUGAR PRICES FOR THE MONTH

Ended June 15, 1921.

	96° Centrifugals		Beets	
	Per Lb.	Per Ton.	Per. Lb.	Per Ton.
May 16, 1921	5.13c	$102.60	No quotation	
" 17	5.12	102.40		
" 18	5.01	100.20		
" 19	5.02	100.40		
" 25	5.06	101.20		
June 1	4.985	99.70		
" 2	4.84	96.80		
" 3	4.63	92.60		
" 7	4.50	90.00		
" 9	4.25	85.00		
" 14	4.00	80.00		

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Progress Report on the Work for the Improvement of Sugar Cane Through Bud Selection.

By A. D. Shamel.

Introduction.

The studies of bud variation and bud selection in the work for the improvement of sugar cane by the writer and associates of the Experiment Station of the Hawaiian Sugar Planters' Association were begun in February, 1920. A brief preliminary report, covering some of the observations made during the spring of 1920, was published in the Hawaiian Planters' Record, Vol. XXII, No. 5, May, 1920. It has been deemed advisable to make a similar brief report of our observations during the season of 1921. No attempt will be made at this time to make a detailed report upon the progress of this work. Data are being accumulated and detailed observations are being systematically secured, showing the exact facts concerning the development and progress of the work, which will be available for publication as soon as this investigation has gone far enough to warrant final conclusions and recommendations. In the meantime, these brief annual progress reports may be of some value to those who are interested in this work and particularly to those who are cooperating or who are planning to cooperate in the practical application of sugar cane selection to plantation conditions.

Object.

The main object of our sugar cane selection work is to isolate and propagate the best strains of the important established and proven sugar cane varieties in Hawaii through the selection and propagation of superior parent plants. In other words, the object of this work is to preserve and improve the superior strains and eliminate the inferior ones of the commercially valuable varieties of sugar cane through systematic bud selection.

Plan of Work.

The plan of work adopted in this investigation has been to make system-

atic studies of performance record plats of sugar cane. These plats are located in the best available plantation fields of the established varieties under investigation. In these plats the characteristics of the individual stalks and stools are studied in a systematic and detailed way, in order to determine and establish definitely the characteristics of the variations and strains of each variety arising from them. This work requires patience, perseverance, and a natural inclination for this kind of study. It is of primary importance from the fact that it is through such studies that standards of selection, both for strains and individual plants in these strains, may be developed for practical field use in the work of locating and securing superior parent stools for planting progeny fields.

In this work, the term *individual plant* is used to define a stool of sugar cane. The term *stool* is used to define the stalks which have arisen from a single eye of the plant cane. In regular plantation sugar cane fields in Hawaii it is usually practicable to identify the individual stools by locating the primary, the secondary, and other related stalks in the case of one-year old plants. With two-year old plants, the identification of individual stools is more difficult. In order to study two-year old stools satisfactorily it has been found advisable to space the plant cane in the experimental and progeny fields so that the individual stools can be readily picked out and definitely located. The term *progeny field* is here used to mean a field planted with plant cane secured from superior parent stools selected by someone trained in this work. In the progeny fields, the progeny of each parent stool is kept together and identified in some way so that the behavior of the different progenies may be compared and, if desirable, traced back to their parent stools. The plantation progeny fields are used (1) for the selection of superior plant material for extending the progeny fields each year, and (2) as sources of superior plant cane for general plantation use. The parent stools selected in the progeny fields for extending these fields are secured by trained men. The plantation plant cane is secured in the progeny fields in the usual manner by ordinary plantation labor. When the plant cane is cut from the progeny fields for plantation use, the writer believes that it is advisable to throw out any small, deformed, or otherwise apparently inferior plant pieces and use only the large, well-developed, and apparently good ones. This plant material is undoubtedly much superior for planting the plantation sugar cane fields to that taken from the general fields where no selection has been practiced.

Observations Upon the Results of Planting Selected Stools.

During the planting season of 1920, experimental plantings of selected stools of sugar cane were made at the Waipio experimental plantation, the Ewa, Onomea, Honokaa plantations, and the Makiki plats of the Experiment Station by the writer and his associates. Other experimental plantings were made by members of the Experiment Station staff or under their supervision or by plantation managers on Maui. In most of these experimental plantings the progeny of each selected parent stool was kept together and arranged in the progeny fields so that it could be identified and studied whenever desirable. In the Waipio and some other plantings the progenies were staked and numbered so that each progeny could be traced back to its parent stool in order that the characteristics of each parent stool could be compared with those of the stools in its progeny.

In February, 1921, a study was begun of these progeny plantings by the following members of the Experiment Station staff: H. P. Agee, J. A. Verret, W. W. G. Moir, Y. Kutsunai, and the writer. Faithful and efficient services in this connection were rendered by Japanese and Filipino laborers, most of whom had participated in the planting of the progeny fields during 1920 and who had shown their adaptability for this kind of work. From time to time other members of the Agricultural Department of the Experiment Station staff than those mentioned above assisted in this field work as their duties permitted, including R. S. Thurston, W. L. S. Williams, and J. H. Midkiff. Mr. W. P. Alexander of the Ewa plantation, and other plantation officials displayed a keen interest in this work and actively assisted in its development upon their respective plantations. Through the active and sincere cooperation of all of the men involved, it was possible during 1921 to systematically study a considerable acreage of progeny plantings and secure definite information regarding the results of sugar cane selection work as a basis for drawing reliable conclusions as to the possibilities of this work for the improvement of the sugar cane industry in Hawaii.

At Waipio the progeny plantings were first gone over in a general way and the behavior of some of the most interesting progenies studied and compared. In this work the best and the poorest progenies were located. It soon became apparent that some of the progenies were very much superior to others in a number of important characteristics, including perfection of stand of stools, the number and size of stalks in each stool, the habit of growth of the stalks, the resistance of the plants to disease, and other important features of plant behavior. As soon as these facts were determined from observation and some comparative measurements, the progenies were then gone over systematically a second time and exact detailed records were secured of certain characteristics of each stalk of each stool in all of the progenies. It became evident in the first survey of the Waipio progeny plantings that in order to study the plantings as a whole within the time available for this purpose and with the limited number of men available for carrying on these studies, it would be necessary to confine the detailed records of plant behavior to a few important plant characteristics. After considerable thought and study of this problem, it was decided to limit these records during the 1921 season to the number of stalks in each stool, the circumference of each stalk, the type characteristics of each stalk, the comparative uniformity of stalks in each stool, certain eye characteristics, with notes upon the resistance to disease or other injuries or any other apparent plant characteristic which might have a bearing upon the inherent value of the plants for propagation. These extremely interesting and very valuable data will not be submitted for publication at this time and are being reserved for a detailed report upon this work when sufficient data have been secured to enable us to present the subject as a whole in a satisfactory manner to everyone concerned.

The individual stalk and stool data secured in the progeny plantings at Waipio were used in making up tables for several progenies showing the standard deviation and coefficient of variability for each progeny. These data enabled us to make definite comparisons of the behavior of the individual progenies and to rank them in the order of their performance from these standpoints. The data also made it possible for us to compare certain definite parent plant char-

acteristics with those of the progenies, in other words, determine the characteristics of the parent plants which were inherent and transmitted to their progenies. The figures secured in these progeny studies made it possible to lay the foundation for the establishment of certain definite standards of selection for parent stools of the varieties studied, a matter of supreme importance in the practical work for the selection of plant cane for progeny fields.

At Ewa it was not possible under the circumstances to make a detailed study of the 600 progenies of the H 109 variety in the progeny field on that plantation. This field was gone over systematically and 972 superior parent stools were selected and planted from it in an additional progeny field for that plantation. After the selected parent stools had been taken out of the Ewa progeny or mother field, the remainder of the stools were used for general plantation planting. This plant cane was apparently much better for this purpose than any that could have been secured from plantation fields where the plant cane had not been selected. A second progeny field of H 109, planted in 1920 on the Ewa plantation, was left for detailed study in 1922 in order to secure data upon the behavior of two-year old plants grown from selected parent stools.

The progeny field of the Yellow Caledonia variety on the Onomea plantation showed very striking results. Individual plant and progeny performance record data are now being secured in this field and selections of superior parent stools are being made for planting an additional progeny field during the present season. The progeny field at the Honokaa plantation, mainly of the D 1135 variety, will be studied during the present summer as opportunity permits, and individual plant and progeny record data secured as a basis for the selection of parent stools for planting an additional mother field. Similar work will be carried on with the Hilo Sugar Company's field of Yellow Caledonia, grown from selected parent stools, and with other similar plantings on other plantations on Hawaii and Maui.

The results of our studies of the experimental progeny fields planted in 1920, located at Waipio and upon several plantations, demonstrate beyond any question of doubt that greatly improved yields of sugar cane can be secured through the selection of superior parent stools as plant material. This increase in production is effected without increase in the cost of production other than that incurred in the selection of the parent stools for the progeny fields, and, therefore, makes possible a marked economy in sugar production and a correspondingly large gain in the profitableness of this business.

The parent stools having uniformly good stalks, selected and planted in 1920, produced uniformly good progenies in 1921, while the poor parent stools produced uniformly poor progenies. The parent stools having some good and some poor stalks produced progenies having some good and some poor stools. These facts establish beyond reasonable doubt in the minds of everyone who studied the progeny fields this season that sugar production can be improved through the selection and planting of superior plant material, i. e., uniformly good parent stools of the best strains in any of the varieties studied, and that this condition will enable the planters to increase their production per acre to a very important and marked degree. It is too early as yet to estimate the amount of the gain in the production of sugar per acre that may be secured

through the selection of superior plant cane, but it can be safely said that the data from the progeny fields planted in 1920 and harvested in 1921 indicate that this gain applied to plantation production as a whole will be more than 25 per cent.

Plan of Planting Sugar Cane Selections During 1921.

After the systematic study of the progeny plantings at Waipio and the analyses of the data secured therefrom, the plants of best progenies were used for planting additional progeny fields at Waipio of the H 109 and Yellow Caledonia varieties. In addition to the propagation of best progenies, a few of the poorest progenies in each variety were propagated for comparative purposes. Each seed piece of all of the stalks used for planting these progeny fields were arranged in the rows in such a way that the new plants from each of these seed pieces can be readily traced back to the parent stools and progenies at any time. In addition to furnishing invaluable data as a basis for sugar cane improvement work, these progeny plantings will provide a considerable amount of genuinely pedigreed plant material for plantation use.

The plants of a few of the best and a few of the poorest progenies at Waipio were propagated as single eye cuttings at the Makiki plats. The single eye cuttings were first planted in pots. When large enough, the young plants were transplanted to the field plats. The germination and growth of these single eye plantings from the carefully selected progenies furnished further positive evidence before they were transplanted of the importance of sugar cane selection. The eyes from the stalks from the good progenies produced a very high percentage of strong germination and the young plants showed a sturdy, strong growth of exceptionally fine appearance. The eyes from the poor progenies showed poor germination and produced spindling and apparently inferior plants. It is probable that from these single eye experimental plantings valuable genetic data can be secured as a basis for guiding selection work, as well as enabling us to measure the progress made through the isolation of the best strains and the selection and propagation of the best stools in these strains.

At Ewa, further selections from the progeny field of apparently superior stools of the H 109 variety were made and in addition to these propagations, Mr. Alexander and associates of this plantation are planning on adding to the progeny field by the additional selection and planting of superior parent plants from some of the best plantation fields.

At Onomea, after the data in the mother field of the progenies of Yellow Caledonia and some other varieties have been secured, plant material will be cut from the superior parent plants of the best progenies for an additional progeny field in order to increase the best progenies as rapidly as possible.

At Honokaa, similar work to that at Onomea will be carried out. At the Papaikou and Hilo Sugar Company plantations additional selections of superior parent stools will be made for the purpose of planting additional progeny fields. If time permits, similar work will be carried on upon plantations on Maui.

Summarizing planting plans for 1921, the experimental plantings made at Waipio and Makiki will furnish data as a basis for measuring the progress of

the work of cane selection and establish to some extent superior sources of pedigreed plant material of H 109, Yellow Caledonia, and two or three other minor varieties. At Ewa, Onomea, Honokaa, and other plantations, additional progeny fields will be established as sources of improved plant cane for these plantations.

Plan of Work for 1922.

During the 1922 season, it is planned to study systematically the experimental progeny plantings on the Waipio and Makiki plats and to secure systematic data regarding the behavior of these progenies. It is planned to devote considerably more time than has been possible heretofore to the establishing of standards for selection of parent stools in all of the varieties under consideration through the study of the behavior of the progenies of the selected parent stools in the progeny fields. This work is extremely important from the fact that before reliable selections of parent stools can be made, definite standards must be determined and agreed upon as to the characteristics of the strains and the stools in the strains for propagation in the progeny fields. It is planned for 1922 that as much time as possible will be devoted to active cooperation with plantations on Oahu, Hawaii, Maui, and Kauai, in order to cooperate with them in the planting of progeny fields as sources of plant cane to be used upon these plantations. In 1922 it will be possible to study the behavior of the two-year old stools in some of the progeny fields planted in 1920, thus enabling us to study the behavior of such plants, particularly their sugar content. It will also be possible to study the ratooning of some of the progeny fields which were harvested in 1921.

Summary of Observations.

The progeny fields studied this season show that some of the parent stools propagated in 1920 produced progenies having uniformly good stools, while others produced progenies with mixed or uniformly inferior stools. From a study of the parent stools and their progenies, we are led to conclude that the parent stools which had *uniformly good stalks* are the ones which produced uniformly good progenies, while the parent stools with one or more poor stalks produced the inferior progenies having good and poor or uniformly poor stools. The differences in production of the uniformly good progenies and that of the poor progenies were very large. The differences in the production of the good and the poor progenies were such as to demonstrate clearly the economic importance of adopting a system of selection in the planting of sugar cane fields. From the evidence secured in the progeny fields this year, the writer has come to the conclusion that greater progress will in all probability be accomplished in improving the production of sugar cane through the selection of superior parent stools of the best strains than has been effected heretofore in the improvement of any other crop through selection and breeding.

Distinct strains have arisen in the sugar cane varieties as a result of bud variation and have been propagated unintentionally by reason of the absence of any method for the systematic selection of superior plant material. Bud variation has been found to be of frequent occurrence in all of the varieties studied

and of great importance from the standpoint of maintaining the productiveness of the varieties which are commonly grown. Many of the sugar cane variations or mutations seem to be atavistic in nature and of inferior commercial value. For this reason the unintentional propagation of the strains arising from these undesirable variations is doubtless the primary cause of the running out or degeneration of the commercial varieties. Some of the variations are doubtless valuable and it seems likely that through isolating these valuable mutations through selection new and improved strains of the important varieties can be secured and maintained for commercial plantation use.

The isolation of the best strains in each of the valuable varieties and their maintenance and improvement through the systematic selection and propagation of superior parent stools having uniformly good stalk characteristics has been demonstrated to be practicable in the progeny fields under plantation conditions.

The standards of selection for parent stools of the best strains of each variety must be worked out through *experimental progeny plantings* and from a continuous and concentrated study of the individual stools, the *characteristics of the stalks of these stools, and the performance records of the progenies of carefully selected stools.*

It seems highly desirable and necessary that in the beginning of the practical application of this work the plantations desiring to adopt it should secure the assistance and cooperation of the men trained in this work from the Experiment Station staff. Several plantations have already offered the services of one or more of their employes, who will work with the Experiment Station men for a time, familiarizing themselves with the methods and practices used in the selection of superior parent stools for propagation in the progeny fields. These plantation men, after the necessary experience and training, will cooperate with the Experiment Station in the planting of progeny fields upon their respective plantations. This arrangement will provide one or more trained men on each plantation who will develop for their plantations reliable and superior sources of plant material for commercial use.

After the progeny fields have become established on a large enough scale to provide adequate plant material for general plantation use, the seed pieces can be cut in the usual way and the planting done as is the ordinary practice. The writer believes that after the seed pieces have been cut in the usual manner in the progeny fields, it will prove to be a desirable practice to throw out any apparently inferior seed pieces and plant only the good ones. This plan will undoubtedly eliminate one of the important causes of poor stands in the fields because the small or weak-looking seed pieces which under this plan will be thrown out and not planted are undoubtedly responsible for much of the poor germination and consequent poor stands sometimes observed. The study of this phase of sugar cane improvement has not gone far enough to warrant final conclusions as to its importance and value, but enough evidence has been observed to show that it can be safely followed with results which will justify the expense of doing it. In other words, in any general lot of seed pieces, such as those secured from progeny fields for plantation use, it now seems advisable

to throw out any apparently weak pieces in order to get an even and vigorous germination so as to secure the best possible stand.

Progeny tests of stools grown from seeds in the work for the origination of new varieties of sugar cane will likely prove to be of great importance in comparing the value of seedlings. In this way it seems probable that the methods of selection worked out in these studies can be used advantageously in the seedling work. These two lines should go hand in hand and both are of fundamental importance to the sugar industry from the standpoint of securing, maintaining, and improving varieties of cane for the production of sugar on the most economical and profitable basis.

CONCLUSION.

The results of the studies of the progeny plantings of the Yellow Caledonia, H 109, D 1135, and other varieties of sugar cane made in 1920 from selected parent stools demonstrate beyond any question that it is possible to increase the efficiency of these varieties for sugar production and, as a result, improve the yield of sugar cane per acre very materially through the selection and propagation of superior parent stools. This information furnishes the reason for sustained and continuous effort in order to perfect methods and standards of selection, to identify and judge the value of the different strains of each variety for commercial utilization upon the plantations in different districts, and to adapt the methods of securing and using improved plant material for plantation use. It seems likely to the writer that with proper support and cooperation on the part of the Experiment Station and the plantations, adequate supplies of superior sugar cane plant material for all plantations desiring it can be established within the next few years.

The work for the improvement of sugar cane through bud selection now being carried on by the Experiment Station of the Hawaiian Sugar Planters' Association may be classified as follows:

(1) The isolation and propagation of the valuable strains and the elimination of the inferior ones of the established varieties.

(2) The selection and propagation of superior parent stools of the best strains in progeny fields.

(3) Securing adequate supplies of improved plant material from the progeny fields for plantation use.

(4) Developing standards for parent stool selection through progeny tests of carefully selected stools.

(5) Searching for and trying out apparently valuable mutations for the origination of new and important strains and varieties of sugar cane.

(6) Determining the frequency of occurrence and the characteristics of bud variation in the varieties under investigation and the relation of the variations to sugar cane improvement.

If the U. S. Department of Agriculture gives the writer a furlough next year similar to that provided for the past two years, he will be glad to accept the invitation of the Director of the Experiment Station and the Experiment Station Committee of the Hawaiian Sugar Planters' Association in order to continue his part in this work during 1922.

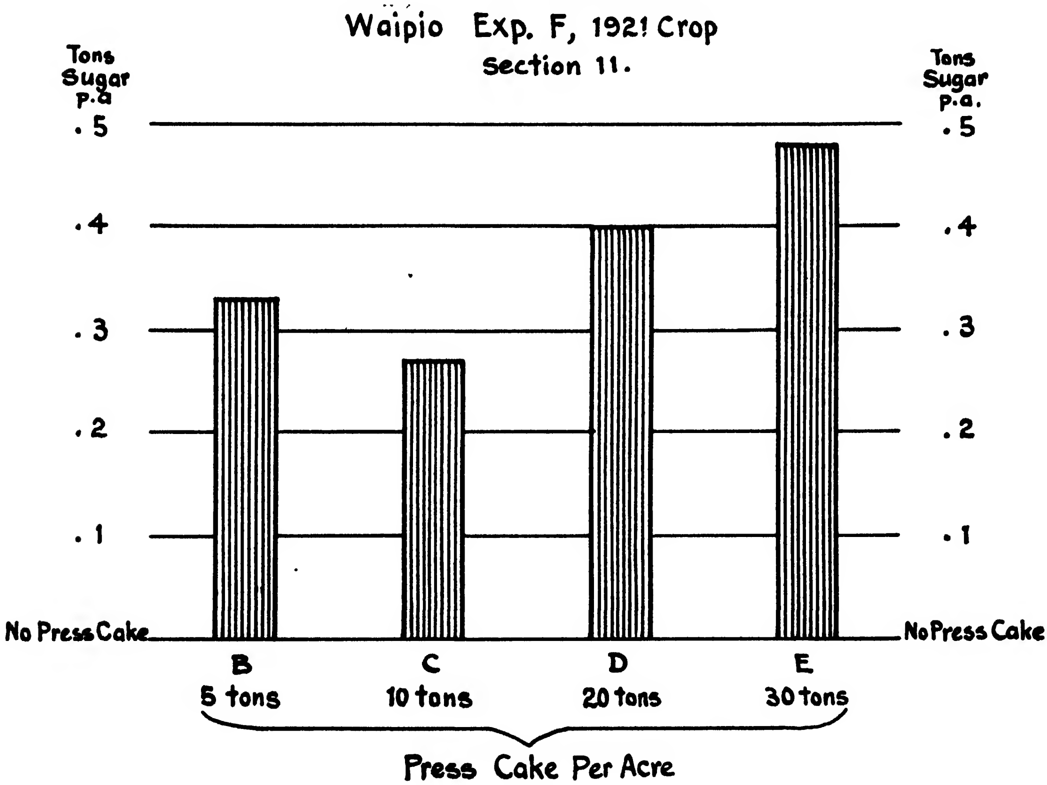
The Fertilizing Value of Press Cake.

WAIPIO EXPERIMENT F, 1921 CROP.

This was an experiment to determine the fertilizing value of varying amounts of press cake used in addition to commercial fertilizers.

The cane was H 109, second ratoons, long, and was 21 months old when harvested. This field had not been irrigated this year, having been carried over from the winter rains. The field was harvested at the end of April. The quality ratio of the juices was 8.24.

Chart Showing Gains Due To Varying Amounts Of Press Cake.



In addition to press cake 1740 pounds of nitrate of soda was applied to all plots.

All plots received a uniform application of nitrate of soda consisting of 1740 pounds per acre. Of this 1160 pounds were applied in August, 1919, and 580 pounds in February, 1920.

The amounts of press cake used and the yields obtained are given below:

No. of Plots	Pounds of Press Cake per Acre (In addition to 1740 pounds of Nitrate of Soda)	Tons per Acre	
		Cane	Sugar
11 A	No Press Cake.........................	104.4	12.67
11 B	5 tons Press Cake.....................	107.1	13.00
11 C	10 tons Press Cake....................	106.6	12.95
11 D	20 tons Press Cake....................	107.2	13.07
10 E	30 tons Press Cake....................	108.4	13.15

The mud press cake used in this experiment had the following composition:

Water .... = 74.18%
Nitrogen .... = 0.36%
Phosphoric Acid (P_2O_5) .... = 1.13%
Potash (K_2O) .... = .12%

The amount of plant food in pounds per acre from the mud press cake applied to the different plots is as follows:

	Nitrogen	P_2O_5	K_2O
A plots	None	None	None
B plots	36	113	12
C plots	72	226	24
D plots	144	452	48
E plots	216	678	72

The press cake was placed in a shallow trench alongside the cane and covered by hand, the dirt being taken from the opposite side of the row.

The press cake in this case increased the yield of cane by about 3 tons per acre, and the sugar by 0.35 ton. This increase was produced by 5 tons of press cake per acre. Larger amounts produced no further gains.

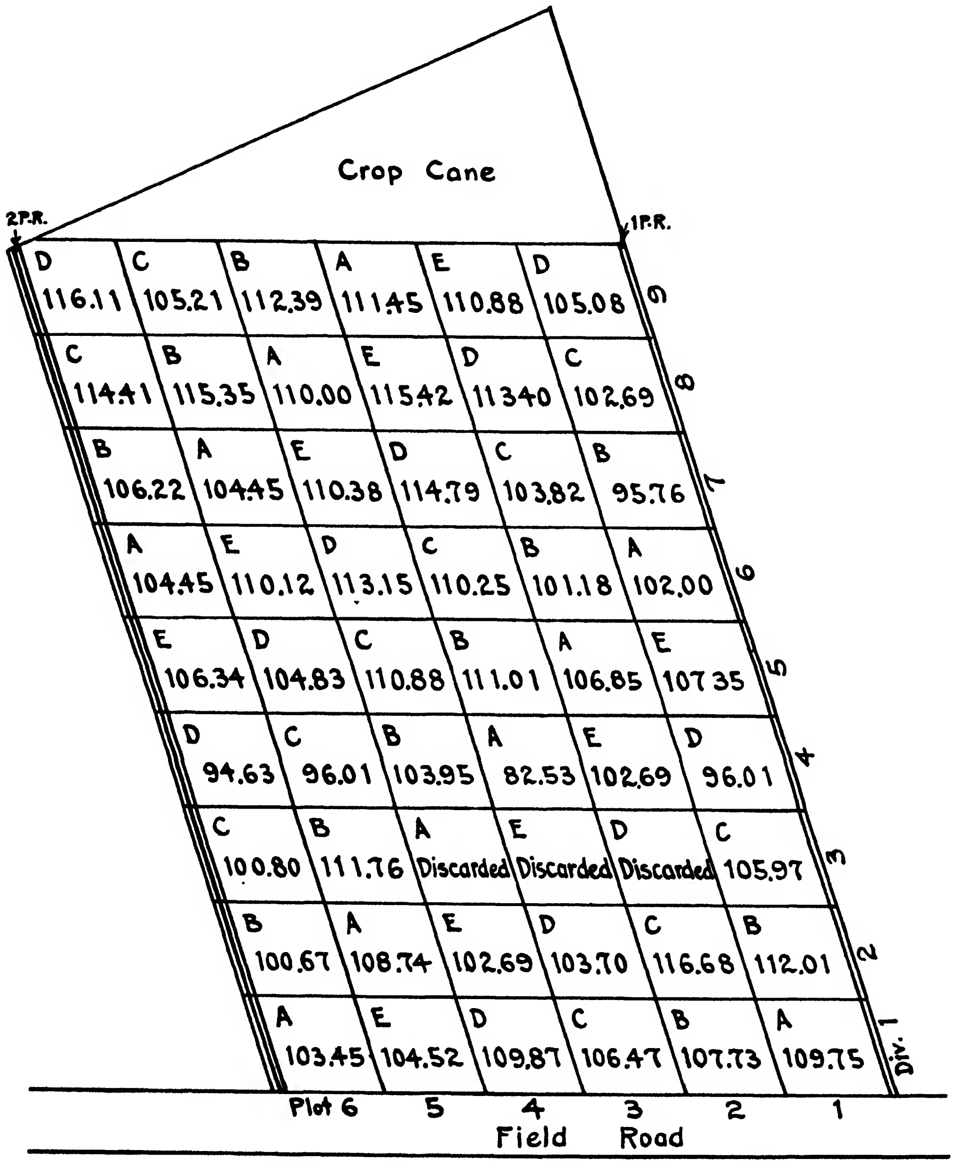
These results are about the same as those reported in the July, 1921, Record, from Waipio experiment U. In experiment U, 10 tons of press cake increased the yield of H 109 9.2 tons of cane per acre when no other fertilizer was used, but when 1740 pounds of nitrate of soda were applied in addition this gain dropped 2.4 tons of cane.

This experiment is being continued to note the effect of press cake on the soil when applied through a series of years.

FERTILIZING VALUE OF PRESS CAKE

Waipio Exp. F, 1921 Crop

Section 11.



Summary Of Results

Plots	No. of Plots	Treatment	Tons Per Acre		Gain or Loss Over "A"
			Cane	Sugar	
A	11	No Press Cake	104.37	12.67	0
B	11	5 tons Press Cake Per Acre	107.09	13.00	+ .33
C	11	10 " " " "	106.65	12.94	+ .27
D	11	20 " " " "	107.16	13.07	+ .40
E	10	30 " " " "	108.38	13.15	+ .48

DETAILS OF EXPERIMENT

WAIPIO SUBSTATION — EXPERIMENT F, 1921 CROP.

Mud Press Cake Test.

Object:

(1) To test the fertilizing value of mud press cake.
(2) To compare the yields from varying amounts of mud press cake.

Location:

Waipio Substation — Section 11.

Crop:

H 109, second ratoons, long.

Layout:

Number of plots: 54.
Area of each plot: 1/30 acre (net).
Number of rows per plot: 8.

Plan:

Mud press cake to be applied as follows:

A plots	None	D plots	20 tons per acre
B plots	5 tons per acre	E plots	30 tons per acre
C plots	10 tons per acre		

Fertilization — uniform:

August 19	1160 pounds Nitrate of Soda
February 20	580 pounds Nitrate of Soda

J. A. V.

New Seedlings at Hakalau.

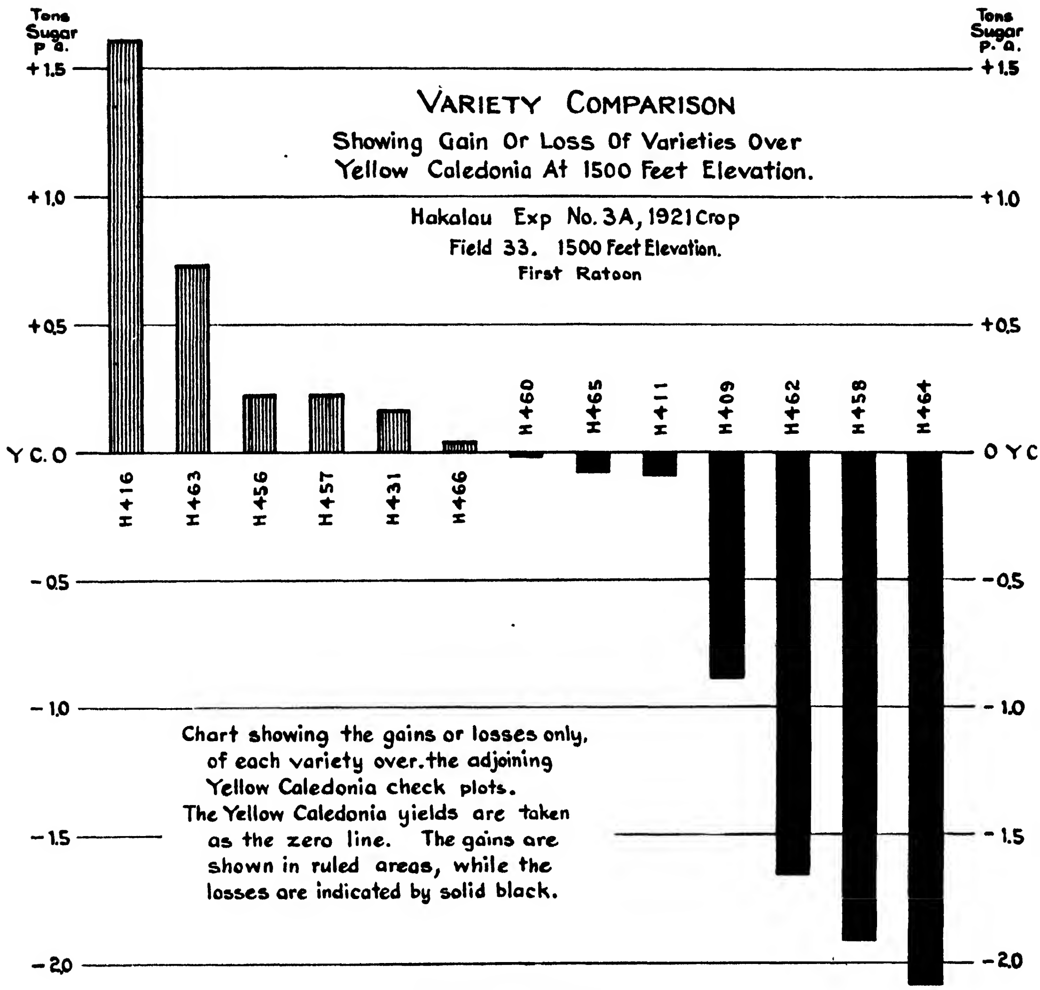
HAKALAU EXPERIMENTS 3A AND 3B.

These experiments compare the standard variety of cane, Yellow Caledonia, with 15 new H seedlings at different elevations. Experiment 3a is at an elevation of 1500 feet, while 3b is at an elevation of 400 feet.

Two crops have now been taken off, one plant and one ratoon. In experiment of 3b at 400 feet elevation none of the seedlings were as good as Yellow Caledonia. The ratoons were especially poor. So poor, in fact, that it was not considered worth while harvesting the experiment.

In experiment 3a at 1500 feet elevation the results were different. Several of the seedlings gave distinctly better yields than the adjoining Yellow Caledonia. This held good for both the plant and the ratoon crop.

The yields obtained at 1500 feet elevation are reported in the following table:



EXPERIMENT 3A

Varieties in Order of Gain or Loss Over Yellow Caledonia, Field 33; Elevation 1500 feet.

Variety	Tons per Acre		Gain or Loss Over Adjoining Yellow Caledonia Plots	
	Cane	Sugar	Cane	Sugar
H 416	50.5	5.38	+ 16.9	+ 1.61
H 463	43.1	4.68	+ 7.9	+ 0.73
H 456	43.8	4.99	+ 1.3	+ 0.22
H 457	53.3	5.10	+ 9.8	+ 0.22
H 431	36.7	4.40	— 1.1	+ 0.16
H 466	36.8	4.59	— 3.7	+ 0.04
H 425	40.3	....	— 0.1	....
H 460	42.7	4.50	+ 2.4	— 0.02
H 465	37.0	4.42	— 3.1	— 0.08
H 411	32.5	3.73	— 1.5	— 0.09
H 409	41.0	4.50	— 7.0	— 0.89
H 462	24.2	2.45	— 12.4	— 1.66
H 458	43.2	3.84	— 8.0	— 1.91
H 464	22.9	2.30	— 16.2	— 2.09
H 427	12.3	....	— 18.7	....

In the table below are given sugar yields for the two crops, with their combined gains over the adjoining Yellow Caledonia, of the five leading varieties.

Variety	Tons Sugar per Acre		Gain Over Adjoining Yellow Caledonia
	Plant	1st Ratoon	
H 416	4.31	5.38	+ 2.96
H 457	6.37	5.10	+ 2.08
H 456	6.61	4.99	+ 1.97
H 463	3.87	4.68	+ 1.97
H 431	4.87	4.40	+ 0.63

Four of the above varieties, especially, are promising, and well worthy of further trial. We plan to lay out a larger experiment at Hakalau as soon as the ratoons from this harvest are big enough to cut for seed.

We note in the above table that H 416 and H 463 produced more sugar from the ratoons than from the plant crop. This indicates good ratooning qualities; something very important when considering varieties for mauka lands. The results of these two experiments, carried through two crops, show the great importance of trying out new varieties of cane under all conditions that obtain on the different plantations. We had here some varieties which were complete failures at 400 feet elevation, that when planted at 1500 feet do much better than Caledonia. It is also best not to condemn a new variety too hastily from the results of a plant crop only. In sending out new seedlings all the seed possible is used, some of which is poor, the planting is not always done at the best season. These different things combine to give the cane a poor start. We therefore recommend that all new seedlings which are at all promising, be grown in small patches through several crops before final judgment be passed upon them. J. A. V.

Rehabilitation.

By Donald S. Bowman.

Industrial Service Bureau, H. S. P. A.

Ewa plantation furnishes us with one of the best examples of what can be done in a sane, practical, economical manner to rehabilitate an old plantation village, creating thereby new conditions which are welcomed by the labor and approved by other parties interested in the well-being of the laborers.

A year ago the Filipino village at Ewa, although originally well planned

Fig. 1. Before remodelling. Two-family house with detached kitchen. Open fire cooking.

Fig. 2. After remodelling, same type house as No. 1. Additional windows. Illustrates method of attaching kitchen, which has a two-foot offset for concrete stove, sink with piped water, and drain board. Owing to the lines of the dwelling roof the kitchen shown was the most practical method of construction. Note hallway with cut-in steps. This provides ventilation, and gives space for working clothes, shoes, etc.

Fig. 3. Before improvement. Alley showing whitewashed detached kitchens, home-made fences, etc.

Fig. 4. After improvement. Same alley as No. 3. Detached kitchens, outhouses and fences removed, replaced by sanitary outbuildings, neatly stained, with yards uniformly fenced by plantation.

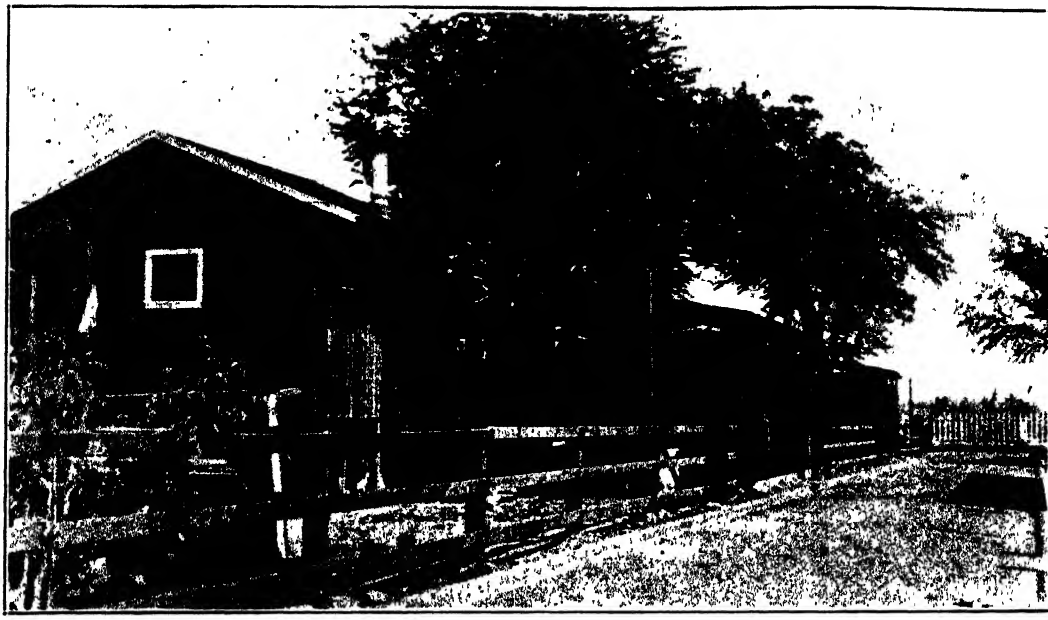


Fig. 5. After improvement. Sanitary outbuilding on alley line. Note attached kitchen and convenience of arrangement.

as to streets and size of yards, presented the usual features found in the older plantation settlements. The houses were of the two-family whitewashed type, with detached kitchens. The kitchens were the regular old-style, non-ventilated smoke-houses, open fires being the ordinary cooking arrangement. Wooden drains carried off the waste water. Although small concrete-floored wash-racks were provided, they served but a small portion of the population. The women

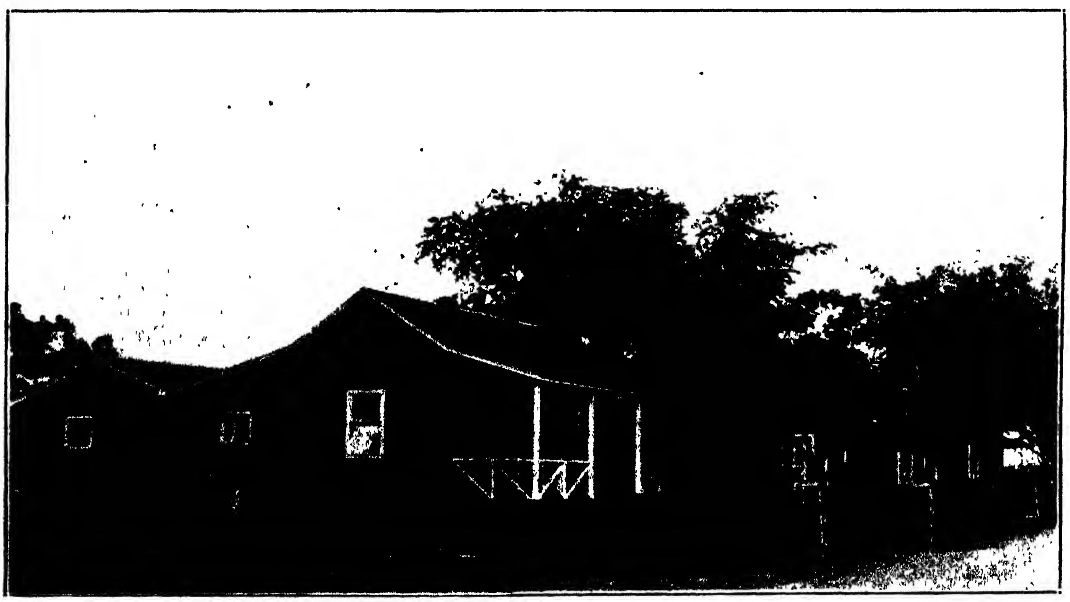


Fig. 6. After improvement. Remodelled dwellings, fenced-in, neat, attractive yards, trees and shrubs planted along streets.

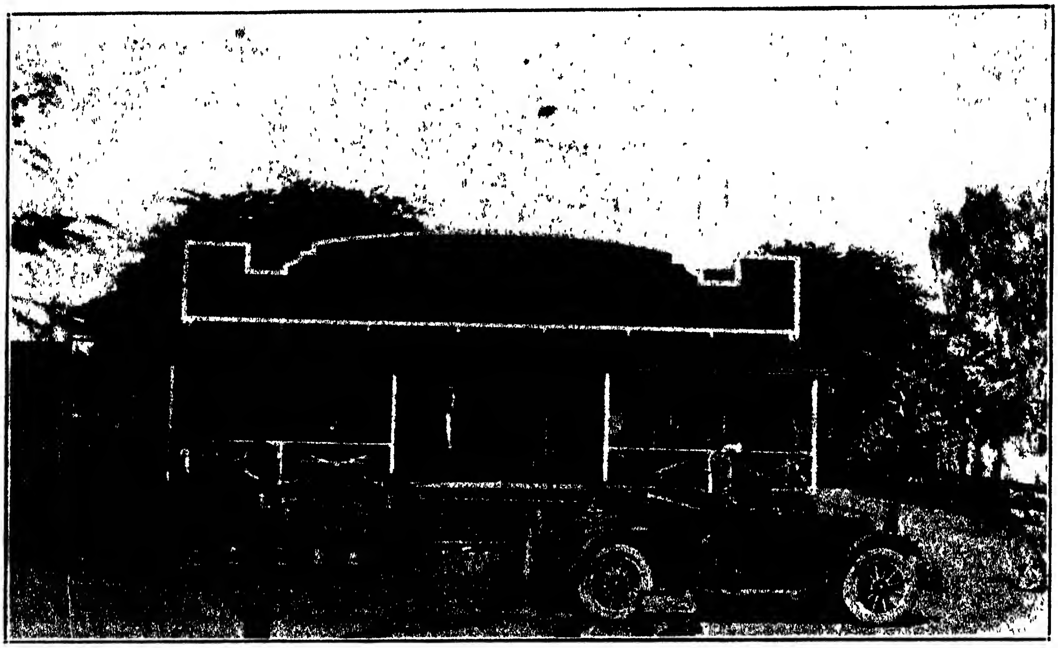


Fig. 7. New plantation branch store and refreshment room. A great convenience for the community and a paying investment from all points of view.

usually did the family washing in the cookhouse, owing to the distance of the central washing floors.

The disposal of human waste was by the dry-earth system, the unsightly outhouses being situated on the alley lines. The village had no attractions, no electric lights, nor any of the features which go to make a village livable.

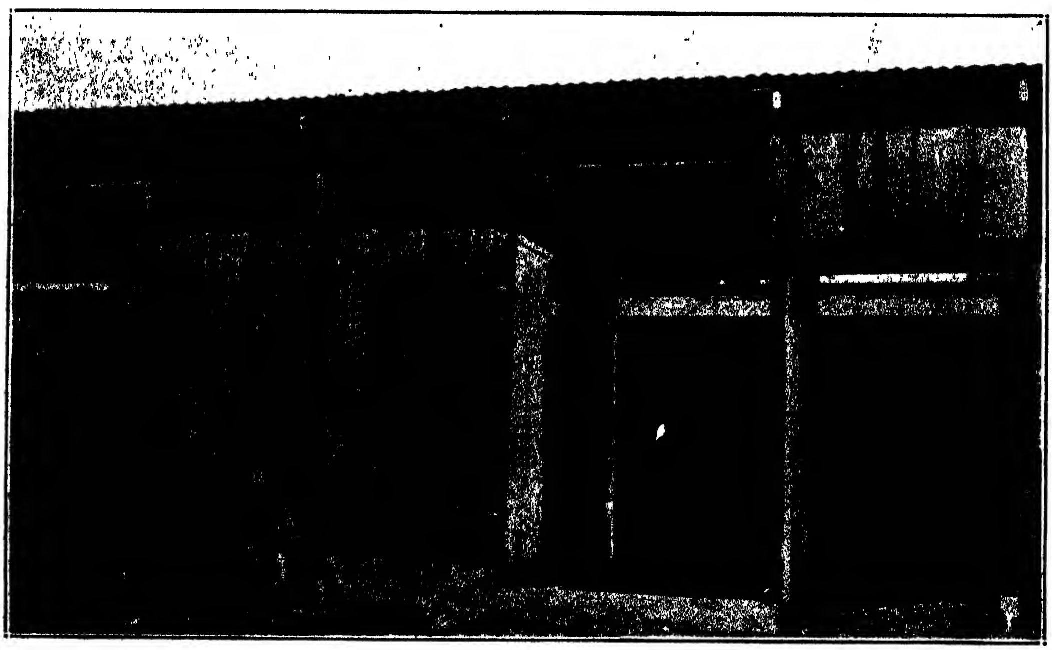


Fig. 8. New sanitary outbuilding, floor plans of which are shown in Figs. 9 and 10.

Fig. 9. Concrete foundation for sanitary outbuilding. This building provides Kentucky privy, wash room with redwood tubs, shower bath and wood shed.

At the request of the manager a survey of the village was made. This was followed by recommendations as to improvements, and these are now being carried out and will soon be completed. The rehabilitation and general improvement so far accomplished consists of the following items:

Remodelled Dwellings:

One hundred and twenty-five old two-family whitewashed dwellings converted into one-family, well-ventilated, stained exterior, attached kitchen cottages, equipped with electric lights, concrete stoves, kitchen sinks, running water, etc. These remade cottages are provided with sanitary outbuildings. Fifty-two more dwellings will undergo the same process.

Sanitary Outbuildings:

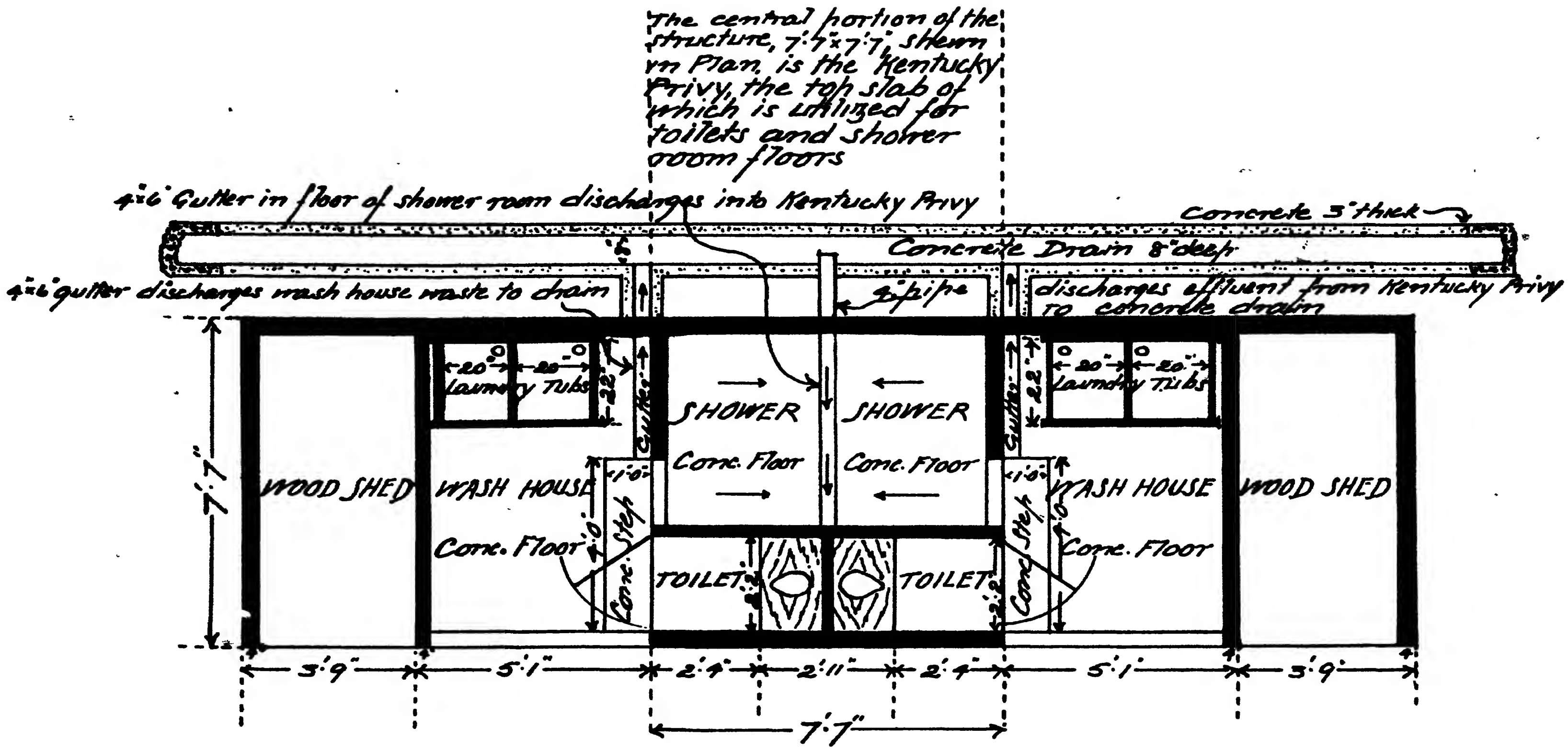
Each dwelling is provided with a sanitary outbuilding as shown in Fig. 8. The foundation of the building is concrete, the central portion being the top of the Kentucky privy. Space is provided for a washroom with stationary redwood tubs, a shower room, privy, and space for the storage of wood.

Club House:

An attractive club house has been provided, which is under the control of the Filipino Social Club. This club house is fitted with pool tables, tables for games, a reading room, player piano, phonograph, and other means of passing a pleasant hour. It is operated and maintained on a self-supporting basis, and there is a profit over and above expenses which is devoted to the purchase of club supplies and equipment. All receipts and expenditures are in the hands of the club, under the supervision of the industrial service worker.

Store:

For the convenience of the villagers a branch store was established, which has proven a great success.



PLAN OF

COMBINATION SANITARY OUTBUILDING

Fig. 10. Floor plan of sanitary outbuilding. Note the compact arrangement which makes use of the top slab of the Kentucky privy.

Electric Lights:

All buildings have been supplied with electric lights, and street lights are placed at regular intervals.

Bicycle Shop:

A bicycle shop is provided, where bicycles may be repaired, rented, etc.

Playground:

A space near the center of the village has been cleared for a playground, and apparatus provided.

Volleyball Courts:

Two volleyball courts are provided for the use of all who care to play.

Sanitation:

The improvements in sanitation have kept pace with the remodelling of the dwellings. Every dwelling is provided with a combination concrete wash, bath, and toilet building, in which space allows for the storage of wood, etc. The waste water and effluent from the Kentucky privies is carried off in concrete drains, which discharge into the irrigation ditches where a constant flow is maintained.

In addition to the above improvements the village has a church, Salvation Army hall, and a parsonage.

The rehabilitation of the village followed out the idea of unit housing, each dwelling being provided with a fenced-in yard and sanitary outbuildings.

The before and after photographs shown are more descriptive of the changes than any word picture we could draw. Work of this kind is most commendable, for there is no waste. At the same time the old buildings, by the expenditure of a very little money compared with the cost of a new dwelling, are made to serve for many years to come.

The transition is thus made from the old order to the new. This kind of work pays not only in prolonging the life of the old dwellings, but in creating more healthful conditions and converting a dull, listless village, with no home interest or community spirit, into a bright, happy settlement, with newly awakened interest in the plantation.

Forms of Nitrogen.

WAIPIO EXPERIMENT D, 1921 CROP.

This was an experiment planned to determine the comparative value of equal amounts of nitrogen when obtained from nitrate of soda, ammonium sulphate, equal amounts of ammonium sulphate and of nitrate of soda, and from dried blood. In addition to the above, complete fertilizer was used on a fifth series of plots. The cane was H 109, first ratoons, long, and 23 months old when harvested. At time of harvest, late June, this field had not been irrigated for slightly over 90 days. The quality ratio of the cane was 7.30.

The treatments applied to the different plots were as follows:

FERTILIZATION — POUNDS PER ACRE

Plots	No. of Plots	Fertilizer per Acre				Pounds		
		September 1919	November 1919	February 1920	May 1920	Nitrogen	P_2O_5	K_2O
A	15	404 lbs. N. S.	404 lbs. N. S.	404 lbs. N. S.	427 lbs. N. S.	250	....	....
B	15	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.	282 lbs. A. S.	250	....	....
C	14	174 lbs. N. S. 174 lbs. A. S.	174 lbs. N. S. 174 lbs. A. S.	174 lbs. N. S. 174 lbs. A. S.	210 lbs. N. S. 140 lbs. A. S.	250	....	....
D	14	1030 lbs. Blood	....	1030 lbs. Blood	....	250	....	....
E	14	305 lbs. A. S. 632 lbs. A. P. 164 lbs. S. P.	305 lbs. A. S.	305 lbs. A. S.	282 lbs. A. S.	250	100	80

The results of the harvest are given below:

Treatment	Tons per Acre	
	Cane	Sugar
Nitrate of Soda..........................	109.0	14.93
Ammonium Sulphate	107.3	14.70
Nitrate of Soda and Ammonium Sulphate ..	107.0	14.66
Dried Blood	105.8	14.50
Complete fertilizer	110.6	15.15

The yields obtained from the varied treatments differ but little from each other. Complete fertilizer produced slightly more cane and sugar than did any of the other treatments, but the gains were not large enough to pay for the extra cost when compared with the nitrate of soda plots. The best financial returns were obtained from the nitrate of soda plots. Dried blood gave the lowest yields at the highest cost per unit of nitrogen.

DETAILS OF THE EXPERIMENT.

Fertilizer Experiment — Forms of Nitrogen.

Object:

1. To compare the relative value of the following forms: Nitrate of soda, ammonium sulphate, mixture of ½ nitrate of soda and ½ ammonium sulphate, and organic nitrogen (dried blood).
2. To compare complete fertilizer (nitrogen, phosphoric acid, and potash) with nitrogen alone.

Location:

Waipio Substation, Section 7.

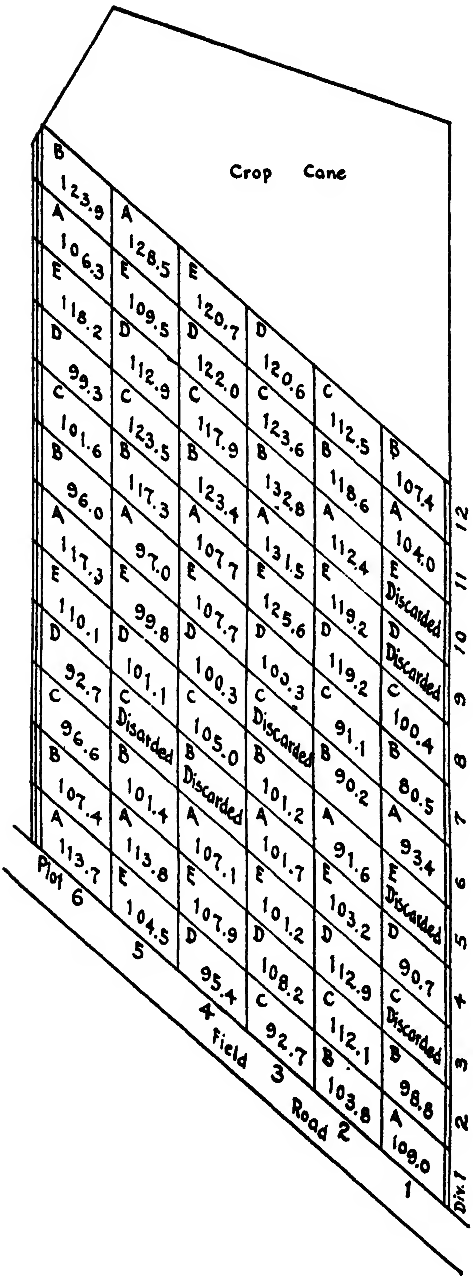
Crop:

H 109 First Ratoons, long.

FORMS OF NITROGEN

Waipio Substation Exp. D, 1921 Crop

Section 7.



Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre Cane	Yields Per Acre Sugar
A	15	1616* Nitrate of Soda	109.00	14.93
B	15	1220* Ammonia Sulphate	107.32	14.70
C	14	696* Nitrate of Soda 696* Ammonia Sulphate	107.01	14.66
D	14	2060* Dried Blood	105.81	14.50
E	14	1616* Ammonia Sulphate 632* Acid Phosphate 164* Sulphate of Potash	110.62	15.15

Layout:

Number of plots = 72.
Size of plots = 1/30 acre (net).
Eight lines per plot.

Plan:

Fertilization in pounds fertilizer per acre.

Plots	No. of Plots	First Season		Second Season	
		Aug. 1919	Nov. 1919	Feb. 1920	May 1920
A	15	404 lbs. N. S.	404 lbs. N. S.	404 lbs. N. S.	404 lbs. N. S.
B	15	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.
C	14	367 lbs. ½ A. S., ½ N. S.	367 lbs. ½ A. S., ½ N. S	367 lbs. ½ A. S., ½ N. S.	367 lbs. ½ A. S., ½ N. S.
D	14	1030 lbs. Dried Blood	....	1030 lbs. Dried Blood	....
E	14	305 lbs. A. S. 632 lbs. P_2O_5 164 lbs. K_2O	305 lbs. A. S.	305 lbs. A. S.	305 lbs. A. S.

J. A. V.

Amount of Fertilizer and Number of Applications.

Hilo Sugar Company Experiments 4 and 5, 1917, 1919, and 1921 Crops.[1]

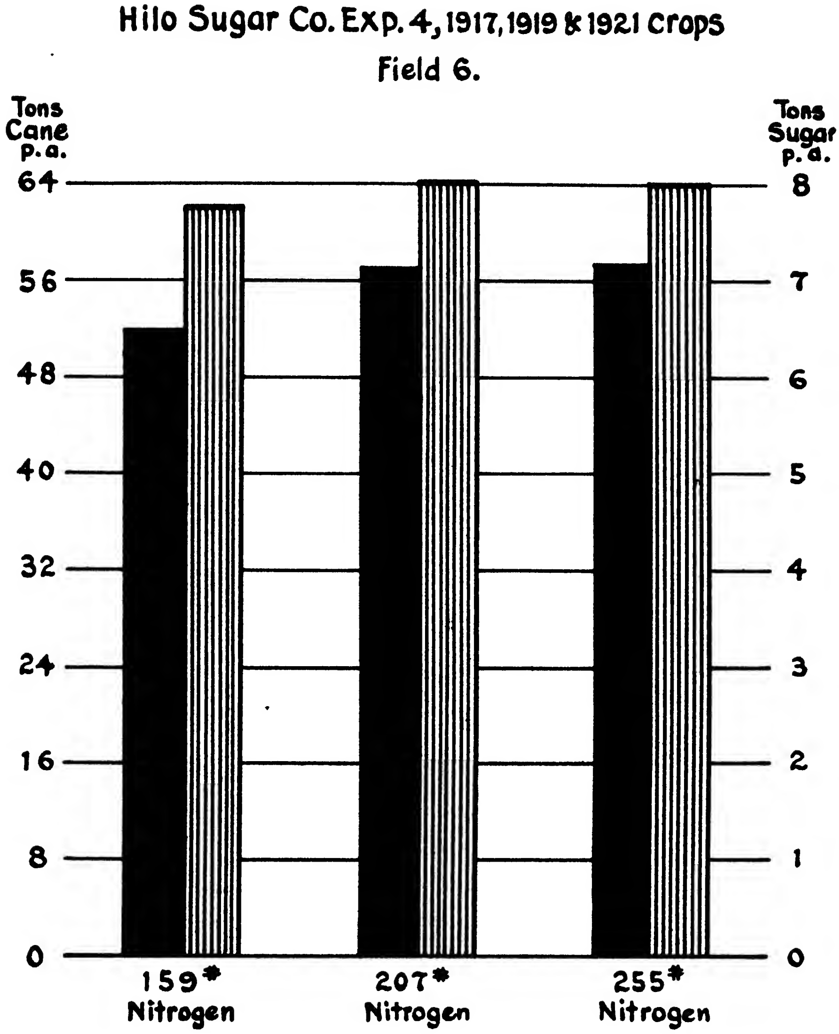
These were experiments planned to determine the most profitable amount of fertilizer to use during the second season, and the best number of doses in which to apply it. The tests were carried out entirely on ratoons, the 1917 crop being first ratoons.

During the first season all plots received uniform fertilization, the amount used being according to plantation practice, and consisted of nitrate of soda and mixed fertilizer. During the second season varying amounts of nitrogen were used and applied in one, two and three doses.

The treatments given and the results obtained for the different crops are summarized in the following tables:

[1] See Planters' Record, Vol. XVII, p. 97; Vol. XXI, p. 270.

Amount To Apply



HILO EXPERIMENT NO. 4—1917 CROP.

Amount to Apply

Treatment		Total Nitrogen	Tons per Acre	
First Season	Second Season		Cane	Sugar
935 lbs. Complete Fert[2]	375 lbs. Spring Dressing[3]	146	57.0	8.15
935 lbs. Complete Fert.	750 lbs. Spring Dressing	198.5	57.9	8.20
935 lbs. Complete Fert.	1125 lbs. Spring Dressing	251	58.6	8.22

[2] Complete fertilizer = 10% N., 7% P_2O_5, 4½% K_2O.

[3] Spring dressing = 14% N., 4% P_2O_5.

HILO EXPERIMENT NO. 4 — 1919 CROP

Amount to Apply

Treatment		Total Nitrogen	Tons per Acre	
First Season	Second Season		Cane	Sugar
250 lbs. N. S., 1000 lbs. B 5[1]	300 lbs. C 1[2]	202	61.2	8.76
250 lbs. N. S., 1000 lbs. B 5	600 lbs. C 1	255	61.9	8.83
250 lbs. N. S., 1000 lbs. B 5	900 lbs. C 1	308	62.2	8.86

[1] B 5 = 11% N., 8% P_2O_5.
[2] C 1 = 17.75% N.

HILO EXPERIMENT NO. 4 — 1921 CROP.

Amount to Apply

Treatment		Total Nitrogen	Tons per Acre	
First Season	Second Season		Cane	Sugar
250 lbs. C 2[1], 500 lbs. B 6[2]	339 lbs. B 5[3]	130	47.1	6.37
250 lbs. C 2, 500 lbs. B 6	677 lbs. B 5	168	51.4	7.07
250 lbs. C 2, 500 lbs. B 6	1016 lbs. B 5	206	51.7	6.94

[1] C 2 = 15% N., 9.5% K_2O.
[2] B 6 = 11% N., 6% P_2O_5.
[3] B 5 = Same as previous.

HILO EXPERIMENT NO. 4 — AVERAGE OF THREE CROPS (1917, 1919, and 1921).

Amount to Apply

Average Pounds of Nitrogen per Acre	Tons per Acre	
	Cane	Sugar
159 Pounds	51.8	7.76
207 Pounds	57.1	8.03
255 Pounds	57.5	8.01

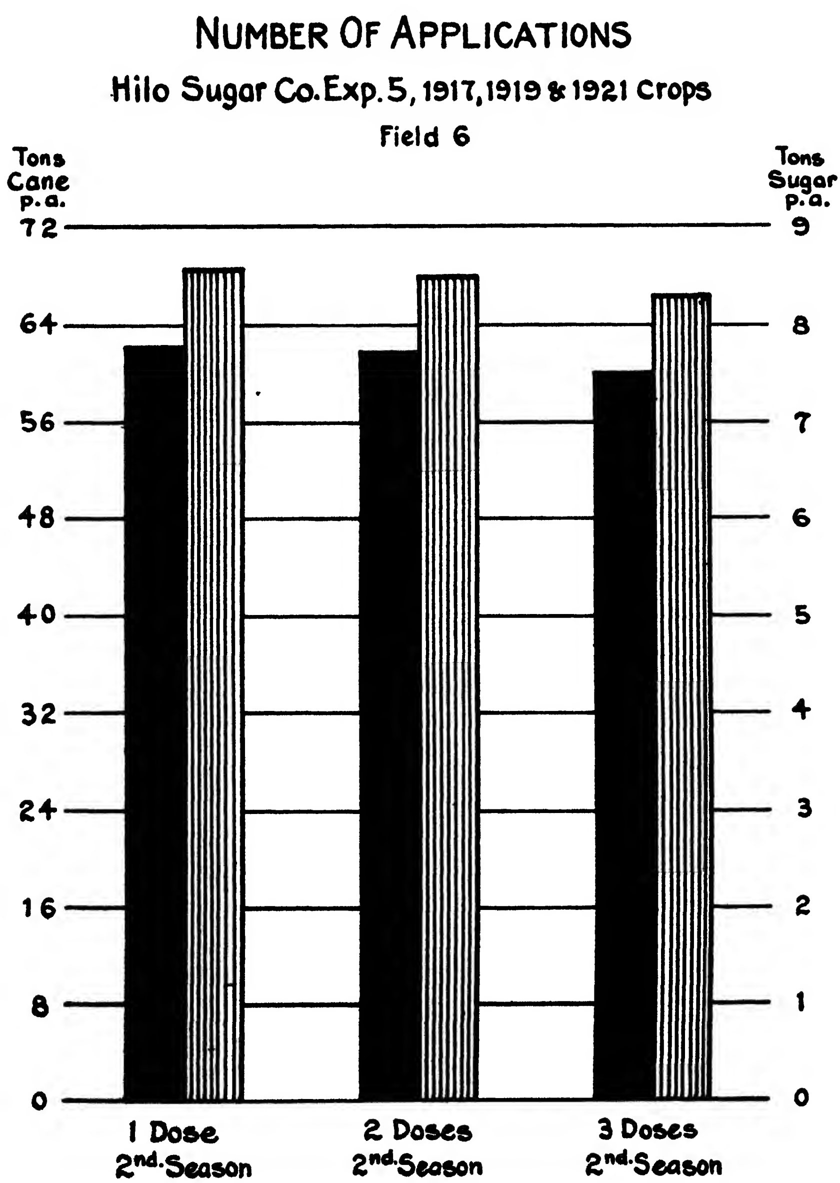
HILO EXPERIMENT NO. 5 — 1917 CROP.

Number of Applications.

Number of Applications		Tons per Acre	
First Season	Second Season	Cane	Sugar
Three applications	One application	66.7	9.42
Three applications	Two applications	64.8	9.11
Three applications	Three applications	61.3	8.62

HILO EXPERIMENT NO. 5—1919 CROP.
Number of Applications.

Number of Applications		Tons per Acre	
First Season	Second Season	Cane	Sugar
Three applications	One application	64.7	8.73
Three applications	Two applications	65.6	8.88
Three applications	Three applications	64.2	8.66



HILO EXPERIMENT NO. 5—1921 CROP.
Number of Applications.

Number of Applications		Tons per Acre	
First Season	Second Season	Cane	Sugar
Two applications	One application	55.6	7.61
Two applications	Two applications	55.1	7.57
Two applications	Three applications	54.8	7.63

HILO EXPERIMENT NO. 5—AVERAGE OF THREE CROPS (1917, 1919, and 1921).

Number of Applications	Tons per Acre	
	Cane	Sugar
One second season	62.3	8.59
Two second season	61.8	8.52
Three second season	60.1	8.30

In experiment No. 4, we find, as the result of three crops, that the profitable limit of nitrogen application was reached with about 200 pounds of nitrogen per acre. In this connection it is well to call attention to the fact that on account of war conditions very little potash was used during the time of these experiments. The soils in the Hilo district are responding in a marked manner to potash applications. It is possible that with liberal potash applications the cane would be able to utilize larger amounts of nitrogen. Experiments are under way to determine this point.

In regard to the results from the number of applications, we find that the returns are as good or better when the fertilizer is applied in one dose during the second season, rather than in more. Results of a similar nature are being obtained right along in other experiments being harvested on the different islands. With present labor conditions, when it is so difficult to get work done properly, we believe all fertilizing should be done in not more than three applications per two-year crop. Two doses only would not be extreme. At the present time it is difficult to get the fields properly cleaned before fertilizing. Cutting down in the number of applications will help there. It is also well to bear in mind that late fertilization during the second season lowers the quality of the juices, more particularly that from the fields first harvested.

DETAILS OF EXPERIMENTS.

Hilo Sugar Company Experiment No. 4—1921 Crop.

Second Season Fertilization—Amount to Apply.

Object:

To compare different amounts of fertilizer when applied in a given number of doses.

Location:

Hilo Sugar Company, field 6, plots 46–90 incl., adjoining Experiment No. 5 on the Hilo side.

HILO SUGAR CO. EXP. 4 & 5, 1921 CROP

Experiment 4. Amount To Apply.
Experiment 5. Number Of Applications.
Field 6.

Exp. 4.	Exp. 5.
46A 47.03	1 A Discarded
47D 57.44	2 B 55.23
48G 57.57	3 C 47.64
49A 42.92	4 A 49.46
50D 49.21	5 B 48.28
51G 51.32	6 C 59.52
52A 45.61	7 A 57.42
53D 49.50	8 B 55.14
54G	9 C 54.33
55A	10 A 52.72
56D	11 B 50.70
57G	12 C 50.52
58A	13 A 50.91
59D	14 B 56.63
60G	15 C 54.84
61B	16 D 57.88
62E Discarded	17 E 54.24
63H	18 F 53.11
64B	19 D 54.57
65E	20 E 48.97
66H	21 F 49.68
67B	22 D 49.85
68E	23 E 55.32
69H 48.45	24 F 54.06
70B 46.66	25 D 57.80
71E 56.70	26 E 56.79
72H 56.04	27 F 57.44
73B 56.09	28 D 63.86
74E 59.61	29 E 62.64
75H 45.88	30 F 53.08
76C 45.51	31 G 59.04
77F 49.88	32 H 62.43
78I 52.31	33 I 63.74
79C 55.90	34 G 66.18
80F 58.17	35 H 63.27
81I 59.67	36 I 59.80
82C 44.82	37 G 54.45
83F 47.26	38 H 49.22
84I 45.99	39 I 56.08
85C 42.89	40 G 54.04
86F 48.97	41 H 55.46
87I 51.03	42 I 56.10
88C 43.31	43 G 52.93
89F 47.12	44 H 52.04
90I 49.20	45 I 51.48
140.7'	140.7'

1392'

Road

Exp. 4. Summary of Results

Amount To Apply	Tons Per Acre Cane	Tons Per Acre Sugar
129.5 Pounds of Nitrogen	47.1	6.37
168 " " "	51.4	7.07
205.5 " " "	51.7	6.94

Exp. 5. Summary of Results

Number Of Applications	Tons Per Acre Cane	Tons Per Acre Sugar
2 First Season, 1 Second Season	55.6	7.61
2 " " 2 " "	55.1	7.57
2 " " 3 " "	54.8	7.63

Crop:

Yellow Caledonia, Third Ratoons.

Layout:

Number of plots = 45. Size of plots = 1/10 acre, consisting of 6 furrows, 5.16′ wide by 140.7′ long.

Plan:

First Season Fertilization — Uniform

Plots	No. of Plots	Lbs. C 2 per acre Sept., 1919	Lbs. B-6 per acre Dec., 1919 *	Total Nitrogen
All	45	250	500	93.75

Second Season Fertilization

Plot	No. of Plots	Lbs. B-5 per acre Mar. 15, 1920	May 15, 1920	July 1920	
A	5	338.7	0	0	
B	5	169.4	169.4	0	37.25
C	5	112.9	112.9	112.9	
D	5	677.4	0	0	
E	5	338.7	338.7	0	75.51
F	5	225.8	225.8	225.8	
G	5	1016.1	0	0	
H	5	508.0	508.1	0	112.87
I	5	338.7	338.7	338.7	

* Depending on growth of cane — otherwise 500 pounds in February.

Experiment planned by L. D. Larsen.
Experiment laid out by L. D. Larsen and J. S. B. Pratt, Jr.

Hilo Sugar Company Experiment No. 5 — 1921 Crop.

Fertilization — Number of Applications.

Object:

To compare different numbers of applications for varying amounts of fertilizer.

Location:

Hilo Sugar Company, field 6, plots 1–45 incl., on the Hilo side of the narrow field road that extends makai from the top of the field.

Crop:

Yellow Caledonia, Third Ratoons.

Layout:

Number of plots = 45. Size of plots = 1/10 acre, consisting of 6 lines, 5.16′ wide and 140.7′ long.

Plan:

First Season Fertilization — Uniform

Plots	No. of Plots	Lbs. C-2 per acre Sept., 1919	1 Lb. B-6 per acre Dec., 1919 *; Feb., 1920		Total Nitrogen	
All	45	250	250	250	93.75	
	Second Season Fertilization					
No. of Applications	Plots	Lbs. B-5 per acre				
1	A	338.7			37.26	Mar. 15, 1920
	D	677.4			75.51	
	G	1016.1			112.87	
2	B	338.7			37.27	Mar. 15, 1920
	E	677.4			75.51	May 15, 1920
	H	1016.1			112.87	
3	C	338.7			37.27	Mar. 15, 1920
	F	677.4			75.51	May 15, 1920
	I	1016.1			112.87	July 15, 1920

* Depending on growth of cane — otherwise 500 pounds in February.

Experiment planned in 1916, by L. D. Larsen.
Experiment laid out in 1916, by L. D. Larsen and J. S. B. Pratt, Jr.

J. A. V.

Amount of Fertilizer, Time of Application, and Forms of Nitrogen.

MAKEE SUGAR COMPANY, EXPERIMENTS 1, 2, AND 3.

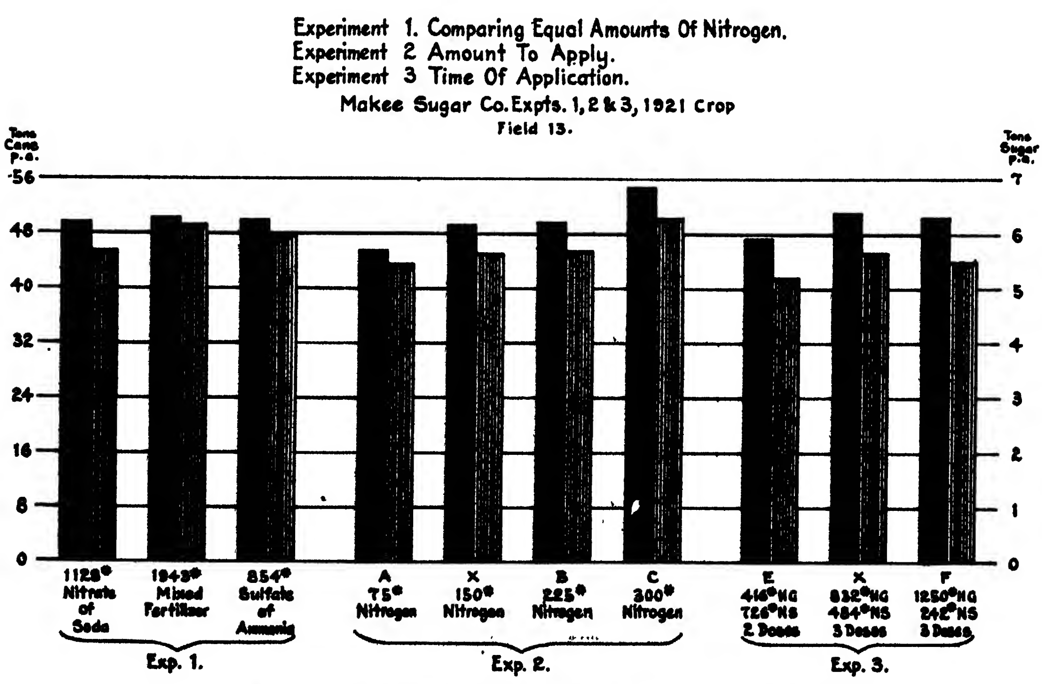
These experiments have now been carried on for two crops, one plant and one ratoon. They are laid out in Field 13. The field is irrigated and planted to Yellow Caledonia cane.

Makee Sugar Company, Experiment No. 1.

This experiment compares equal amounts of nitrogen from nitrate of soda, ammonium sulphate, and from mixed fertilizer containing 9 per cent nitrogen and 7 per cent phosphoric acid.

The treatments to the different plots are given as follows:

No. of Plots	Fertilizer—Pounds per Acre	Total Pounds	
		Nitrogen	P_2O_5
10	1128 lbs. nitrate of soda, in 3 doses...............	175	0
8	1943 lbs. mixed fertilizer, in 3 doses...............	175	135
10	854 lbs. ammonium sulphate, in 3 doses............	175	0



Key:- Solid Bar = Cane. Shaded Bar = Sugar. H.G. = High Grade. N.S. = Nitrate of Soda.

The results obtained in the two harvests are given in the following table:

Treatment	Tons Cane per Acre		
	1919 Crop	1921 Crop	Average
Nitrate of Soda..................................	63.1	49.6	56.3
Mixed Fertilizer	64.3	50.2	57.2
Ammonium Sulphate	62.8	49.8	56.3

The mixed fertilizer plots, in addition to the nitrogen, received 135 pounds of P_2O_5 (equal to 844 pounds of acid phosphate) per acre, yet these plots produced but very little more per acre than the plots receiving no phosphoric acid, thus indicating the need of very little phosphoric acid at the present time.

Makee Sugar Company, Experiment No. 2.

This experiment was to determine the economic limit in nitrogen applications. During the first growing season mixed fertilizer was used, containing 9 per cent nitrogen and 7 per cent phosphoric acid; during the second season nitrate of soda was applied. On account of war conditions no potash was used.

The amounts of fertilizer used on the different plots are tabulated below:

No. of Plots	Fertilizer—Pounds per Acre	Nitrogen	P_2O_5
11	243 lbs. mixed fertilizer, 134 lbs. Nit. Soda........	75	17
12	486 " " " 269 " " "	150	34
11	729 " " " 403 " " "	225	51
11	972 " " " 537 " " "	300	68

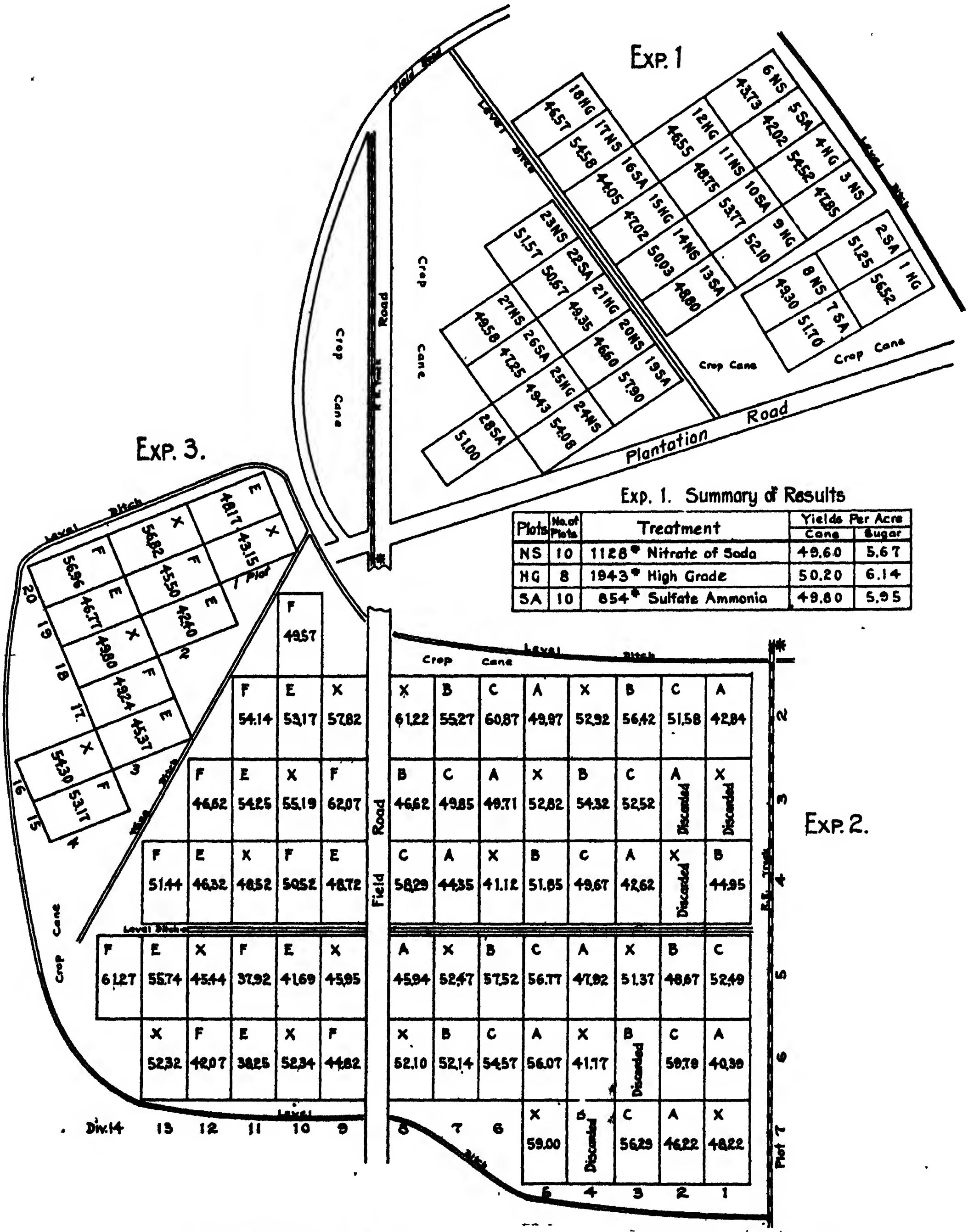
The results for each crop and the average are given as follows:

Pounds of Nitrogen	Tons of Cane per Acre		
	1919 Crop	1921 Crop	Average
75	62.7	45.5	53.6
150	67.0	49.2	58.1
225	66.6	49.6	58.1
300	67.5	54.8	61.1

In the plant crop the profitable limit in nitrogen application was reached with 150 pounds per acre. The ratoons seem to require more, as the "300 pounds of nitrogen" plots gave distinctly more sugar per acre. Before arriving at definite conclusions we deem it best to repeat this test on one or two more ratoon crops.

Experiment 1. Comparing Equal Amounts Of Nitrogen.
Experiment 2. Amount To Apply.
Experiment 3. Time Of Application.

Makee Sugar Co. Expts. 1, 2 & 3, 1921 Crop
Field 13.



Exp. 1. Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre	
			Cane	Sugar
NS	10	1128# Nitrate of Soda	49.60	5.67
HG	8	1943# High Grade	50.20	6.14
SA	10	854# Sulfate Ammonia	49.80	5.95

Exp. 3. Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre	
			Cane	Sugar
E	11	2 Doses, 416# H.G., 726# N.S.	47.40	5.22
X	11	3 Doses, 832# H.G., 484# N.S.	51.10	5.67
F	14	3 Doses, 1250# H.G., 242# N.S.	50.40	5.52

H.G. = High Grade. N.S. = Nitrate of Soda.

Exp. 2. Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre	
			Cane	Sugar
A	11	75# Nitrogen	45.50	5.44
X	12	150# Nitrogen	49.20	5.65
B	11	225# Nitrogen	49.60	5.68
C	11	300# Nitrogen	54.80	6.28

Makee Sugar Company, Experiment No. 3.

In this experiment we attempted to determine what proportion of fertilizer to add each season. The cane was Yellow Caledonia plant and first ratoon, two crops having been harvested.

The fertilizer applications are shown in the following tables for the two crops:

Plots	No. of Plots	Division of Fertilizer						
		1919 Crop—Plant				1921 Crop—1st Ratoon		
		1st Season		2nd Season		1st Season		2nd Season
E	12	1/4	0	3/8	3/8	1/4	0	3/4
X	11	1/4	1/4	1/4	1/4	1/4	1/4	1/2
F	12	3/8	3/8	1/4	0	3/8	3/8	1/4

The yields obtained from the two crops are as follows:

Amt. Fert. per Season		Total Nitrogen	Tons Cane per Acre		
1st Season	2nd Season		1919 Crop	1921 Crop	Average
1/4	3/4	150 lbs.	66.5	47.4	56.9
1/2	1/2	150 lbs.	65.6	51.1	58.3
3/4	1/4	150 lbs.	64.0	50.4	57.1

It does not seem to make a very great deal of difference as to how the fertilizer is divided, yet the tendency is very definitely in favor of applying half or more of the fertilizer during the first growing season. The ratoon crop, which responded more to the fertilizer than did the plant crop, shows this tendency rather strongly.

DETAILS OF EXPERIMENTS.

Makee Sugar Company, Experiment No. 1, 1921 Crop.

Forms of Nitrogen.

Object:

To compare nitrogen in the form of: 1, nitrate of soda; 2, sulphate of ammonia; and 3, mixture of nitrate, sulphate, and organic nitrogen.

Location:

Field 13, Makee Sugar Company.

Crop:

Yellow Caledonia, first ratoons, long.

Layout:

Number of plots = 28.

Size of plots = 1/10 acre (90′ x 48.4′), consisting of 20 lines, each 4.5′ x 48.4′.

Plan:

Fertilization in pounds nitrogen per acre:

Plot	No. of Plots	Plot No.	Fertilizer	Pounds Nitrogen per Acre			Lbs. N. Total
				Aug. 15, 1919	Nov. 15, 1919	Feb. 15, 1920	
NS	10	3, 6, 8, 11, 14, 17, 20, 23, 24, 27....	Nit. Soda	50	50	75	175
HG	8	1, 4, 9, 12, 15, 18, 20, 25...........	High Grade	50	50	75	175
SA	10	2, 5, 7, 10, 13, 16, 19, 22, 26, 28....	Sul. Ammo.	50	50	75	175

NS = 15.5% nitrogen.
HG = 9% nitrogen, (3% sulphate, 3% nitrogen, 3% organic), 7% P_2O_5 (4% acid phosphate, 3% bone).
SA = 20.5% nitrogen.

MAKEE SUGAR COMPANY, EXPERIMENT NO. 2, 1921 CROP.

Fertilizer Experiment — Amount to Apply.

Object:
To determine the most profitable amount of nitrogen to apply, i. e., 75, 150, 225, or 300 pounds per acre.

Location:
Field 13.

Crop:
Yellow Caledonia, first ratoons.

Layout:
Number of plots = 45.
Size of plots = 1/10 acre (48.4'x 90'), composed of 20 straight rows, each 4½'x 48.4'.

Plan:
Fertilization in pounds nitrogen per acre:

Plots	No. of Plots	August, 1919	Nov., 1919	Feb., 1920	Total
A	11	25	25	25	75
X	12	50	50	50	150
B	11	75	75	75	225
C	11	100	100	100	300

Nitrogen to be applied first season in form of plantation High Grade of following composition:

H. G. = 9% N. (3% nitrate, 3% sulfate, 3% organic), 7% P_2O_5 (4% water sol., 3% bonemeal).
N. S. = Nitrate of soda, 15.5% nitrogen.
Second season nitrogen to be applied as nitrate of soda.

MAKEE SUGAR COMPANY, EXPERIMENT NO. 3, 1921 CROP.

Fertilizer Experiment — Time of Application.

Object:
To determine what proportion of the fertilizer to apply each season.

Location:

Field 13.

Crop:

Yellow Caledonia, first ratoons.

Layout:

Number of plots = 36.

Size of plots = 1/10 acre (48.4'x 90'); 24 plots composed of 20 straight lines, each 4½'x 48.4'. The other 13 plots have irregular lines.

Plan:

Proportion of fertilizer applied at different times of year.

Plot	No. of Plots	First Season		Second Season	Total Lbs. N. per Acre
		Aug., '19	Nov., '19	Feb., '20	
E	11	1/4	0	3/4	150
X	11	1/4	1/4	1/2	150
F	14	3/8	3/8	1/4	150

Total amount of nitrogen to be applied = 150 pounds; first season fertilization to be with H. G. and second season with nitrate of soda.

H. G. = 9% N. (3% nitrate, 3% sulfate, 3% organic), 7% P_2O_5 (4% water sol., 3% bonemeal).

J. A. V.

Furnace Design and Boiler Efficiency.*

By D. S. Jacobus.

To approach perfection from a thermal viewpoint, a boiler and superheater, including its economizer and air heater, if used, should absorb a maximum amount of heat with a minimum draft drop. There are commercial elements entering into the problem that limit the application of this principle, and so many variables that each case must be considered by itself in order to arrive at the best arrangement. A relatively large amount of boiler heating surface, with large flow spaces for the gases, if properly insulated to prevent undue radiation, would more nearly meet the requirements of absorbing a maximum amount of heat from a given weight of fuel burned with a minimum draft drop than a smaller amount of surface, although the latter would in most cases be preferable from a commercial point of view. Adding an economizer will ordinarily add to the thermal efficiency.

* Abstract of a paper delivered before the Cleveland Engineering Society and local section American Society of Mechanical Engineers at Cleveland, and the Akron section at Akron, Ohio, April 26 and 27, 1921.

Determining Whether an Economizer Will Pay.

To determine whether it will pay to use economizers in a new plant, the problem should not be approached by comparing the efficiency of a boiler with that of the same boiler with an economizer added to it. The proper way is to compare the results to be expected from boilers best suited for the service without the addition of economizers to those to be expected for the best combination of boilers and economizers.

It will sometimes be found for exceptional load conditions that a larger boiler properly designed and baffled will give better commercial returns, all features considered, than a smaller boiler with an economizer — or, for that matter, for any boiler that can be selected with an economizer.

For peak load service it does not usually pay to install economizers on all boilers. A good arrangement may be secured for some classes of service by adding economizers to, say, one-third of the boilers, operating them at a more nearly uniform load than the rest and cutting in those that have no economizers during the peak load periods.

Another case where it does not pay to apply economizers is where boilers are used for stand-by service. The cost of fuel is a governing factor, and because of the increase in fuel costs during the last few years we are approaching more closely to European practice in the number of boilers so fitted.

In designing a boiler for use without an economizer, additional efficiency may be secured by adding to its height. Increasing it from, say, 14 to 20 tubes high will result in a considerable increase in efficiency without a corresponding increase in the draft loss, as much of the draft loss in boilers comes through the turns made by the gases in passing over the baffles.

To avoid exterior corrosion through the condensation of moisture from the flue gases, the temperature of the feed water to the economizers must be kept above a temperature of about 120° F., and for most work we recommend 140° F., as this allows for some leeway in case the water is fed intermittently.

It is becoming more general practice to use an individual economizer on each boiler and not to install connections for by-passing the gases around the economizer. A by-pass connection as a rule allows some leakage of the hot gases and causes a continual loss of efficiency and its omission is also advantageous in simplifying operation and lessening the chance of trouble with the economizers.

Danger of Overheating Brickwork.

For securing the highest efficiency the furnace temperature should be the maximum that can be maintained, and combustion should be completed within the furnace chamber. The furnace brickwork employed today will fail if saturated with heat at the full temperature that is available with many classes of fuel. In furnace design, therefore, some efficiency must be sacrificed in most cases in order to maintain the furnace brickwork and keep the cost of repairs within a reasonable figure.

Where furnaces are operated under a suction that causes the cool air to be drawn inward through the brickwork, there is a cooling effect that serves

to prevent overheating. whereas if they are operated under a pressure, there is a tendency for the hot gases to leak outward and overheat the brickwork.

Brickwork will fail by plastic deformation before it reaches the melting point. The greater the load carried by the brick, the more likely it is to fail. Fireclay brick of the best quality ordinarily obtainable begins to show plastic deformation under a load of 20 pounds per square inch at from 2200° to 2400° F. Reduction to a load of 10 pounds per square inch will increase the permissible temperatures about 200° F. As furnace temperatures considerably higher than this exist with certain grades of fuel and stoker practice, say 2700° to 3000° F. as a limit, it is apparent that the necessity of maintaining the brickwork below the temperature of the furnace is a vital one. First-class clay bricks have a fusion point slightly above 3100° F. and yield through plastic deformation long before they fuse.

In ordinary furnace design the walls and arches are heated on one side only in order that the brickwork may be maintained at a lower temperature than that of the furnace. A wall of a given thickness that would give good service as a battery wall might fail under the same fuel and combustion if used as a supporting wall between two combustion arches, as the heat would not be conducted away from the wall to the extent that it would when used as a battery wall, and the reflected heat from the arches would also increase its temperature. Such a supporting wall should be used between combustion arches only in cases where a low grade of fuel is burned, which does not result in high temperatures, or it should be ventilated.

To consume the combustible gases within the furnace chamber there should be a proper length of flame travel before the gases strike the tubes and a sufficient furnace volume. Furnace volume and length of flame travel are not, however, the only elements that must be considered in designing an efficient furnace, as there must be a mingling action within the furnace to cause any unconsumed conbustible gases to reach the excess air.

Effect of Radiant Heat Absorption.

The effect of the absorption of radiant heat on the boiler tubes should be considered in designing a furnace. With certain fuels, such as blast furnace gas, wet wood or bagasse, where the highest attainable temperature can be carried by the brickwork, it is best to absorb but little radiant heat in order to maintain a high furnace temperature and thereby increase the efficiency of combustion. With the stronger fuels it is necessary to absorb a considerable amount of the radiant heat in order to prevent the collapse of the brickwork or an undue amount of deterioration.

Exposing more or less of the boiler surface to the direct radiant heat of the fire has a comparatively small influence on the efficiency, as any increase in the heat absorbed through direct radiation is counterbalanced to an extent by the diminution of the amount of heat absorbed through conduction. Ordinarily, the higher the furnace temperature, the higher the efficiency. Higher furnace temperatures, however, lead to increased cost of brickwork maintenance, especially when the boilers are operated at high ratings, and for a strong

fuel it usually pays to expose a considerable proportion of the heating surface of the boiler to the direct action of the radiant heat.

Rating for Economical Operation of Boilers.

The economical rating is naturally influenced by the presence or absence of economizers and the service to which the boilers are put. Where there are short peak-load periods, the greatest commercial economy is usually secured by operating the boilers to as high a capacity as can be secured during these periods.

The general practice in this country is to drive boilers at a higher rating than is done in European practice, and the stress of war conditions has undoubtedly led to a number of plants being run beyond the point of the best commercial efficiency.

A furnace for operating at high capacities should be larger than for operating at low capacities; a furnace to give economical results at high ratings therefore involves special problems in caring for the expansion of the brickwork and especial care in the construction of buckstays for holding the brickwork in alinement. The general tendency in large furnace walls which are highly heated is to bulge inward toward the fire, and unless means are provided to prevent this they may collapse.

In our present practice we use bonding tile, which is held by cast iron bulb pieces attached to the buckstays in such a way that the wall can expand in any direction in a generally vertical plane, whereas it is prevented from either bulging inward or outward. Another means that may be employed to prevent the walls bulging inward toward the fire is to build them with a camber having a vertical axis—that is, curved slightly, with the concave side next the furnace.

Trouble From Slag Adhering to Tubes.

In operating at higher ratings, difficulties are encountered with some grades of fuel through slag adhering to the boiler tubes and restricting or closing up the passageways for the flow of the gases. The difficulty through slag can be reduced by providing a relatively large area for the flow of gases on entering the spaces between the tubes and by furnishing access doors through which the slag can be detached from the tubes. An air lance, which is used both for cooling the slag and as a rod for striking it to remove any portion that may adhere to the tubes, forms an efficient tool for use in connection with the access doors.

With certain grades of coal there will be some accumulation of slag on the boiler tubes with the stokers most carefully operated, and it is advantageous in such cases to provide access doors for removing the slag.

Reducing Clinker Trouble.

Trouble from clinker at the sides and front walls of the furnace where underfeed stokers are used is often reduced by admitting air through a number of openings in the walls at the sides of the fuel bed. The air flows in a layer against the inner face of the wall and prevents the clinker adhering to them. It also serves to partly cool the wall and reduce its erosion.

It can readily be seen that furnace design and boiler design must be co-

ordinated in order to secure the best results. It is impossible to separate boiler efficiency from the efficiency of the stoker and furnace. Many have worked on this problem, and the ground has probably been gone over more thoroughly than any other feature of boiler testing codes. The result has always been in reaching the conclusion that it is impossible to separate the furnace and stoker efficiency from the combined efficiency of the boiler, stoker, and furnace in such a way that the result may not be misleading. W. E. S.

You, Mr. Watertender.*

The following was recently sent out by W. E. Thomson, steam-plant engineer of the Southern California Edison Co., to all watertenders of the company as an appeal to "sell them their jobs." It is well worth the attention of all boiler-plant employers.

Do you, Mr. Watertender, realize that you occupy an important position? You are largely responsible for the lives and safety of others as well as yourself. You have almost as much to do with the efficiency made by your shift as has the fireman. You are the one to see that the water is heated as hot as possible before it leaves the heater so that you gain by using all of the exhaust steam. Heating the water hot before it enters the boiler helps the boiler. It does not have to put so much heat into each pound of water, hence you increase the amount of steam the boiler can make. This increased capacity, especially over the peak load, enables your station to carry more kilowatts. Every eleven degrees you can heat the feed water by using exhaust steam means a saving of one per cent in the amount of fuel oil used on your shift, and almost one per cent gain in boiler capacity.

Watch the Water Level.

By watching the water level in the boiler, you keep the boiler from going dry, perhaps exploding. At one of our plants someone did not watch the water level. The water in a boiler was allowed to get low—way out of sight in the glass. A tube burst. Luckily, no one was injured, as the force of the explosion happened to be sideways into other tubes. But the whole front bank of tubes had to be renewed. The brickwork had to be repaired. The total cost was over $1100, besides the loss from having the boiler out of service.

It is you, Mr. Watertender, who must watch to see that the water does not get too high in the glass. If it does get too high, the water will go over into the steam main. The temperature of the steam is lowered. More steam is required to carry the same load. More oil has to be used to make the steam. Hence your shift efficiency suffers. But this is not all. If enough water goes over, it is likely to wreck some machine. An instance of this happened not long ago. An exciter was wrecked. Fortunately, no one was hurt, but the repairs cost over $500, and for some time, until the parts were received from the fac-

* From "Power."

tory, the other exciters were overloaded and the plant in danger of shutting down any minute. This water, going over into the turbines, corrodes and scales the parts, causing a loss not only to your shift efficiency, but to everybody else's until the machine can be taken out and overhauled.

Feed the Water Gradually.

It is you, Mr. Watertender, who can help your fireman and your shift efficiency by feeding the water into the boilers gradually, not have a valve half open one minute and closed the next, but set the valves so that the water goes into the boiler just as fast as the steam-flow meter shows it is going out. It has been shown by tests that a swinging load will cause a loss of over 5 per cent, and that is just what you get when you feed the water into the boiler by spurts. You get the same action that a swinging load on the plant would cause. If you don't believe this, try it out. Take a reading on the flow meter, then open your feed valve wide and watch the flow meter—drops back, doesn't it? Now, close the feed valve and watch the flow meter—jumps right up, perhaps to a greater reading than you had at the start. Just the same action when you open the valve as if the station load would suddenly drop and the fireman had to cut back on his fires, only in this case the boiler stops steaming so fast, but you are using the same amount of fuel oil in the furnace. If the water is fed regularly, the flow-meter chart will not show any sudden swings and your shift efficiency will thus get the benefit.

Carry Water Level at Half a Glass.

Did you, Mr. Watertender, ever stop to think that by carrying the water level constant at half a glass, your work is made easier and you are in a position to help the fireman out? A sudden demand comes for more steam. All right, you have a half-glass of water, a little extra, so you can shut the feed valve a minute—just long enough so that the boiler output increases because you are not putting cold water into it, but that minute gives the fireman a chance to get his steam pressure up. You can now open the feed a little—very gradually, remember too fast will cause the steam to drop again—and slowly work your water levels up to half-glass again.

This little extra work on your part has kept the steam from getting away down so that both you and the fireman would have had to work for perhaps an hour to get it up. Now, suppose your water levels are back to half a glass again, and the fireman is carrying his steam high so as to get the best efficiency; a little load drops off, a boiler pops. All right; once more you can save. The boiler popping can stand a little more water; you open the feed valve. The popping stops almost immediately. The extra water you let in had to be heated. You have saved the steam that was going to waste through the pop valve. The fireman has now cut back on his fires a little so you can regulate the feed again until you have the half-glass of water showing in the gage.

Blowing Down the Boilers.

It is you, Mr. Watertender, who is responsible for blowing down the boilers—for keeping the concentrate in the boilers below 200 so that the boilers

will not prime. It is you who must keep the concentrate as near 200 as possible, so that heat will not be wasted by too much blowing down. Every time a boiler is blown down unnecessarily, it means a loss of approximately ten gallons of oil.

When a boiler is on stand-by, it is you, Mr. Watertender, who should report it in writing to the fireman if the boiler keeps filling up so you have to blow it down to keep the glass from getting too full. It is you who should report it to the fireman if the stand-by boiler keeps losing water so you have to open the feed valve to keep the water in sight in the glass. In both these cases hot water is being wasted and you are in a position to catch these wastes before anybody else. A barrel of water wasted in either of these cases means a gallon of oil lost.

It is you, Mr. Watertender, who must blow down the water column and gage glass on each boiler at least once a shift so that you are sure the water level shown is correct. Otherwise these lines may become clogged, the glass show water and still the boiler go dry, perhaps explode, kill someone and wreck the plant. [W. E. S.]

Sugar Cane Experiments in the Leeward Islands.

The Imperial Department of Agriculture for the West Indies has recently issued a report summarizing the results obtained from Sugar Cane Experiments conducted in Antigua and St. Kitts-Nevis in the season of 1918–19. The report is divided into two parts. Part I is devoted to experiments with varieties of sugar cane, while Part II deals with the results obtained from manurial experiments.

We give below the conclusions they have arrived at from the results of their manurial experiments:

SUMMARY OF CONCLUSIONS DRAWN FROM MANURIAL EXPERIMENTS IN THE LEEWARD ISLANDS, 1891 TO 1916.

In the Report on Manurial Experiments with Sugar Cane for 1915–16, Dr. Tempany has given (pp. 49–52) a general summary of the whole of the results achieved in the Leeward Islands up to the year 1915. The main conclusions may be outlined as follows:

A. Plant Canes.

1. Pen manure, applied at the rate of 20 tons per acre, gives a remunerative increase of the cane crop.
2. Any addition of pen manure above the amount stated does not produce further remunerative increase.
3. The addition of artificial fertilizers to the basal dressing of 20 tons of pen manure per acre does not result in further remunerative increase.

4. The limiting factor in the growth of the cane crop is, on the whole, its water supply.
5. It is essential for the maintenance of a high degree of fertility in the cane field soils that the percentage of humus in them should be kept at an adequate figure; this is achieved by the addition of pen manure of the amount above mentioned.
6. Phosphatic manures appear to have little beneficial effect on the yield of plant cane in the Leeward Islands.
7. Lime applied to heavy clay cane soils is beneficial in that it ameliorates the texture of the soil and so improves many of the growth conditions.

   Lime, applied in small dressings with a view to correcting soil acidity, seems to have little beneficial effect. This subject, however, is still under investigation, and no conclusive statements can yet be made.
8. Molasses, applied as a manure to plant canes, gives appreciable increase in yields.

B. *Ratoon Canes.*

The general conclusions drawn from experiments on the manuring of plant canes hold good also for ratoon canes, with the following qualifications:

1. Early applications of quick-acting nitrogenous manures, such as sodium nitrate, ammonium sulphate, and calcium nitrate, in dressings conveying about 40 pounds of nitrogen per acre to the cane soils, have a beneficial effect in stimulating the growth of new stems from the old stools, especially during seasons of normal or high rainfalls.
2. Molasses seems to be of little value in increasing the yield of ratoon canes.
3. Intertillage is beneficial when applied in the early stages of growth of ratoon canes.
4. Manures, applied to plant canes or to first ratoon canes, may exert an appreciable effect on succeeding crops of first ratoons and second ratoons, respectively.

The results of the 1915–16–17 experiments with plant canes led to conclusions which, on the whole, did not differ markedly from those already drawn from the long series of experiments carried out between 1891 and 1915. It was decided, therefore, in 1917, to discontinue the experiments and to inaugurate in their place another series, the aim of which was to concentrate on the essential features which have emerged, and to secure by means of an increased number of repetitions of each experiment, in each season, a more rapid accumulation of results. (See Report on Sugar Cane Experiments in the Leeward Islands for 1915–16, p. 52.)

RESULTS OF THE NEW SERIES OF MANURIAL EXPERIMENTS WITH SUGAR CANE AT ST. KITTS IN 1917-18, AT BRIGHTON ESTATE.

Manurial Treatment	Plot	Tons Cane per Acre	Mean	Percentage Gain Over No Manure
1. No Manure	1 a	22.5	16.4	....
	1 b	14.6		
	1 c	16.2		
	1 d	13.5		
	1 e	17.1		
	1 f	14.8		
2. Pen Manure, 20 tons per acre..	2 a	24.3	23.4	+ 42.7
	2 b	25.2		
	2 c	25.2		
	2 d	17.8		
	2 e	24.9		
	2 f	23.1		
3. 40 lbs. nitrogen as sulphate of ammonia, with potash and phosphate	3 a	30.3	25.3	+ 54.3
	3 b	27.7		
	3 c	27.0		
	3 d	23.4		
	3 e	19.6		
	3 f	24.0		
4. 60 lbs. nitrogen as sulphate of ammonia, with potash and phosphate	4 a	29.3	26.0	+ 58.5
	4 b	23.2		
	4 c	25.9		
	4 d	21.6		
	4 e	25.6		
	4 f	20.4		
5. 40 lbs. nitrogen as nitrate of soda, with potash and phosphate......	5 a	24.7	26.3	+ 60.3
	5 b	30.8		
	5 c	26.1		
	5 d	25.0		
	5 e	22.0		
	5 f	29.0		
6. 60 lbs. nitrogen as nitrate of soda, with potash and phosphate......	6 a	23.0	25.1	+ 53.0
	6 b	24.1		
	6 c	24.9		
	6 d	21.3		
	6 e	32.2		
	6 f	25.2		
9. 60 lbs. nitrogen as sulphate of ammonia, without potash and phosphate	7 a	23.6	21.1	+ 28.6
	7 b	22.2		
	7 c	20.9		
	7 d	18.0		
	7 e	23.2		
	7 f	18.4		

Manurial Treatment	Plot	Tons Cane per Acre	Mean	Percentage Gain Over No Manure
10. 60 lbs. nitrogen as nitrate of soda, without potash and phosphate...	8 a 8 b 8 c 8 d 8 e 8 f	19.1 12.8 20.9 16.9 14.8 18.0	17.1	+ 4.3
12. Filter-press cake 2 tons per acre..	9 a 9 b 9 c 9 d 9 e 9 f	14.2 17.8 17.7 11.3 15.8 12.2	14.8	— 9.8
13. Cotton-seed meal 600 lbs. per acre.	10 a 10 b 10 c 10 d 10 e 10 f	20.2 19.5 16.9 10.8 21.6 14.8	17.3	+ 5.5

The following conclusions may perhaps legitimately be drawn from the results of this new series of experiments:

1. The manures applied may be grouped into three classes: (a) quick-acting nitrogenous plus potash and phosphate (Nos. 3, 4, 5, and 6); (b) quick-acting nitrogenous manures *without* potash and phosphate (Nos. 9 and 10); and (c) organic manures (Nos. 2, 12, and 13).

2. The highest increase in the mean yields of the manured plots has been given by combinations of quick-acting nitrogenous manures plus potash and phosphate (Nos. 5, 4, 3, and 6, arranged in order of magnitude of increase produced).

3. Pen manure has given an increase almost as large as that due to the combinations mentioned in the last paragraph.

4. In the absence of potash and phosphate, quick-acting nitrogenous manures have not given marked increase in yield.

5. The organic manures—filter-press cake and cotton seed meal—have either depressed the yield, or have increased it to an insignificant amount. This result is difficult to interpret, and it would be unwise to discuss its meaning until a continuation of the experiments has furnished further evidence.

It appears that the most profitable manure to use for plant canes in St. Kitts, *in the absence of pen manure,* is a complete manure supplying per acre about 40 pounds of nitrogen contained either in ammonium sulphate or sodium nitrate, together with potassium sulphate (to supply 60 pounds of K_2O) and basic slag (to supply 40 pounds of P_2O_5).

Apparently, from the results of the season's experiments, potash is a very important ingredient. Phosphate, perhaps, is of less value as has been shown

in the combined results of manurial experiments carried out over a great number of years.

Further results of experiments along the above lines may in future years confirm the generalizations set out in the above statements. Especially may they be hoped to throw new light on the question of the importance of potash as a constituent of a general artificial manure to replace pen manure in manuring the cane crop in St. Kitts.

J. A. V.

Clarification of Cane Juice for the Manufacture of White Sugar, Using Magnesium Acetate.*

Mr. Migaku Ishida, of the Sugar Experiment Station, Formosa, has published a bulletin[1] in which he proposes a new method of juice clarification for white sugar manufacture, called by him the "double ammonio-defecation process." His method of operating is to heat raw juice, treat with ammonia and magnesium acetate, subside, treat with milk of lime, and again subside. This procedure is said to raise the purity about 7°, "the expense in the sugar factory per picul of sugar being about one-third of the ordinary carbonatation process." The quality of the sugar produced by the new process is said to be "better than No. 25 of the Dutch standard, and nearly the same as that of the double carbonatation process, and better than that produced by sulphitation"; while the yield is stated to be, if not higher, certainly not lower than in other processes. Some extracts from this publication (which is the first technical bulletin in English issued by the Formosa Station) may be made.

Laboratory Experiments.

The writer's first plan was to improve the ordinary defecation process; and with this purpose in view the effect of several reagents was tried, the best results being obtained with ammonia and ammonium acetate, followed by lime. It was intended to employ some colloidal substance, as aluminum or magnesium hydroxide, which could be prepared from the sulphate by the use of ammonia or other alkali; and it was finally decided to utilize a magnesium compound, "as it is readily obtainable and at a low cost."

This new method of forming magnesium hydroxide in the juice seemed to be very efficient in its clarifying action. A 15 per cent solution of ammonia, and a 1.81 per cent solution of magnesium acetate, were prepared; and a number of experiments carried out, some of the conclusions from which are as follows: (1) Caramel is removed from its solution by these reagents, 75 c.c. of a solution of caramel being treated with 3 c.c. of ammonia (15 per cent), and 10

* From International Sugar Journal, May, 1921.

[1] Bulletin No. 1, entitled "A Contribution to the Chemistry of the Clarification of Cane Juice and of Sugar Manufacture," by Migaku Ishida, published by the Government Sugar Station, Formosa, Japan. It contains 62 pages.

c.c. of magnesium acetate (1.81 per cent), boiled and filtered, when on examining the degree of color in the Stammer instrument it was concluded that caramel had been eliminated. (2) Solutions of dextro-rotatory amino-acids, and of amino-acid amides, are rendered optically inactive. (3) Glucose in the proportion in which it occurs in cane juice is not affected by the new treatment, nor is levulose.

Incidentally, it occurred to the writer that the proposed reagents might be applied as a clarifying treatment in the analysis of raw cane juices, the procedure being to take 50 c.c. of juice and add 10 c.c. of magnesium acetate (1.81 per cent), and 5 c.c. of ammonia (15 per cent), to complete to 100 c.c. with water, and to filter. As a control, 2 c.c. of basic lead acetate were added to 50 c.c. of the same juice, the volume made up to 100 c.c., and the liquid filtered. The polarization in both cases was the same, viz., 19.70.

In the laboratory experiments on the application of magnesium acetate as a possible technical process, lime was not used at first. In one of the experiments, 0.14 c.c. of 15 per cent ammonia, and 0.28 c.c. of 1.82 per cent magnesium acetate solution, were added to every 100 c.c. of the raw juice. Originally the purity was 78.80, but this treatment raised this value to 82.26°. Less satisfactory results were obtained with smaller amounts of the reagents.

Later, however, it was observed that a further improved effect could be realized by the use of lime after adding the two reagents. For example, in one of the writer's experiments 500 c.c. of raw juice heated to 80° C. were treated with the reagents at the rate of 0.08 c.c. of ammonia, and 0.25 c.c. of magnesium acetate solution per 100 c.c., and allowed to subside an hour. At the end of this time the clear liquid was drawn off, treated with milk of lime (15°. Bé.) at the rate of 0.4 c.c. per 100 c.c. of juice. Another lot of 500 c.c. of the same juice was submitted to ordinary defecation, by adding 2 c.c. of milk of lime 15° Bé.), and heating to boiling point, and subsiding. These were the results obtained:

	Brix	Polarization	Purity
Raw cane juice	17.9	13.8°	77.09
Ordinary defecation	18.8	15.0°	79.79
New double clarification	18.0	15.3°	85.00

Other tests showed that the effect of the new process was to remove 80 per cent of the pectins and gums, 25 per cent of the nitrogenous substances, and about 30 per cent of the ash. Calcium oxide increased about 60 per cent of that originally present in the raw juice.

Application on the Factory Scale.

It is pointed out that in applying these reagents to factory practice, only a few additions to the ordinary equipment would be necessary, viz., more subsiding tanks and a set of Danek filters for the syrup.

The writer proposes to prepare the ammonia from ammonium sulphate and calcium hydroxide (using an apparatus similar to that of Grueneberg); while

magnesium acetate would be made from the carbonate and acetic acid, keeping the liquid alkaline to litmus.[2] Concluding, it is stated that "this new process has proved its worth theoretically and practically, and has been shown to be easily applicable to the ordinary raw sugar factory. Its reagents . . . . . can be prepared in any sugar factory. Besides, the yield is not low (no inversion occurring), and the sugar produced is of a high grade, while neither the expense of the clarifying agents nor the cost of production exceeds that of other processes." [J. A. V.]

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[2] Magnesium carbonate is quoted on the London market today at about £30 per ton, f. o. b., including packages; and acetic acid (80 per cent) at about £48 per ton.—[Editor I. S. J.]

SUGAR PRICES FOR THE MONTH

Ended July 15, 1921.

	96° Centrifugals		Beets	
	Per Lb.	Per Ton.	Per. Lb.	Per Ton.
(June 16, 1921).......	4.00c	$ 80.00	No quotation	
" 21...............	4.25	85.00		
" 23...............	4.00	80.00		
" 28...............	4.28	85.60		
" 29...............	4.00	80.00		
" 30...............	4.3125	86.25		
*July 1...............	4.625	92.50		
** " 5...............	4.3125	86.25		
" 6...............	4.3125	86.25		
" 7...............	4.1875	83.75		
" 11...............	4.375	87.50		
" 14...............	4.5992	91.984		
" 15...............	4.50	90.00		

* Covers a purchase for export purposes and does not reflect regular domestic consumption market.

** July 5th information one sale four cents, another 4.625; latter export.

THE HAWAIIAN
PLANTERS' RECORD

Volume XXV. SEPTEMBER, 1921 Number 3

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Plant Selection. Those who are following the work of plant improvement locally will find interest in articles in this issue, one dealing with the selection of rice in Java, the other describing a dwarf coconut which is reported to have arisen as a mutation.

The New Leafhopper Enemy. The new leafhopper enemy, *Cyrtorhinus mundulus,* has been found to be very numerous in one locality at Olaa plantation. This is of particular interest in view of earlier reports of the rather discouraging way in which the insect has failed to multiply as had been expected. At Ewa plantation it was thought to be held in check by the kissing bug, which, according to Mr. Muir, is not so plentiful in the area at Olaa where the new leafhopper enemy is thriving.

Mr. Pemberton reports from Queensland that he has found another species of *Cyrtorhinus* which has habits apparently identical to the one which has been brought to Hawaii. If experiments now under way fully establish the fact that it is entirely a beneficial insect, an effort will be made to colonize it here.

Experiments with Potash. Distinct gains were obtained from potash applications in Onomea. No response whatever was obtained from phosphoric acid at the same place. It appears that 62 pounds of potash (125 pounds of sulphate of potash) can be applied with distinct profit, and that the economic limit may lie somewhat beyond this amount.

A test at Hamakua Mill Company showed some increase in yield from potash applications. All of the plots received some potash, so the results are not as clear cut as we would like. The laboratory results in this case do not show a particularly low potash content, and offer an exception to the correlations we have frequently noted between soil analysis and crop response.

In an experiment at McBryde we failed to get better yields from applications of phosphoric acid or potash in addition to the ordinary nitrogen fertilization. These results confirm those obtained two years ago in the same locality.

Wireworm Injury and Its Control. The chances of obtaining a natural enemy of the wireworm, which is doing damage at Hamakua, are materially strengthened by news from Dr. F. X. Williams, at Los Banos, P. I., that he has found a parasite on another and smaller species of wireworm than the one occurring here.

Fertilizer—How to Apply. A field test at **Waipio gave** yields that were essentially the same whether the fertilizer was divided into two, three, or four applications. The differences under the several treatments were hardly more than a ton of cane, notwithstanding the fact that the yields ran in the neighborhood of 110 tons of cane per acre. The cane was H 109, 24 months old. There were twelve repetitions of each treatment.

Results of the same character were also obtained in varying the proportion of fertilizer between the first and second season. The differences in cane weights were unimportant regardless of whether fertilizer was divided half in half between the two seasons, or one-fourth the first season and three-fourths the second season, or the reverse of this—that is, three-fourths the first season and one-fourth the second. Greater variation was found in the sugar than in cane yields, but Mr. Verret feels that these differences are due more to difficulties in sampling and to varying intervals of time between burning and sampling at the mill, rather than to the fertilizer treatments themselves.

The Sugar Cane Leafhopper and Its Parasites in Hawaii.*

By F. Muir.

The Leafhopper.

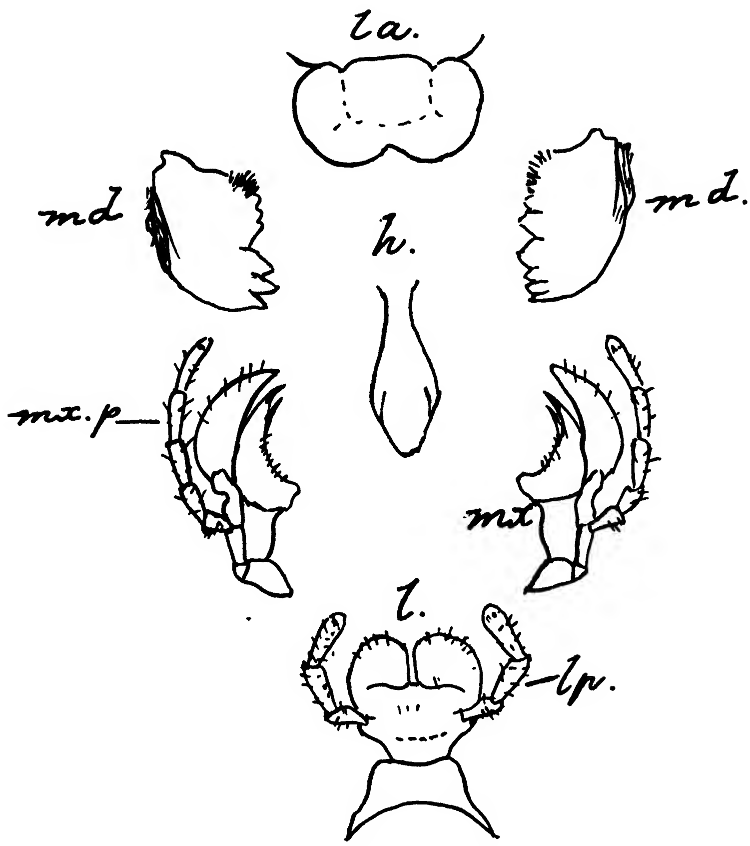
Most plantation men are well acquainted with the sugar cane leafhopper as it appears in the field, and many are acquainted with the damage it can do. Those whose memories go back to 1903–4–5 know the conditions that the plantations had to face before any effective control of the hopper had been found. But there are many men on plantations today whose personal knowledge does not go back so far, and conditions over the greater part of the islands are such that the leafhopper does not force itself upon their notice. To such these remarks are mainly addressed:

The sugar cane leafhopper belongs to the Order Hemiptera. The chief features of all the insects in this Order are the shape and arrangement of the

* A lecture delivered at the University of Hawaii in the Short Course for Plantation Men, October, 1920.

mouth parts and their method of functioning. Upon these also depend the nature of the damage done by the leafhopper.

In an ordinary mandibular or masticating insect, such as a cockroach, or grasshopper, there are six external organs situated around the oral opening or mouth (Fig. 1).



Mouth parts of a masticating insect.

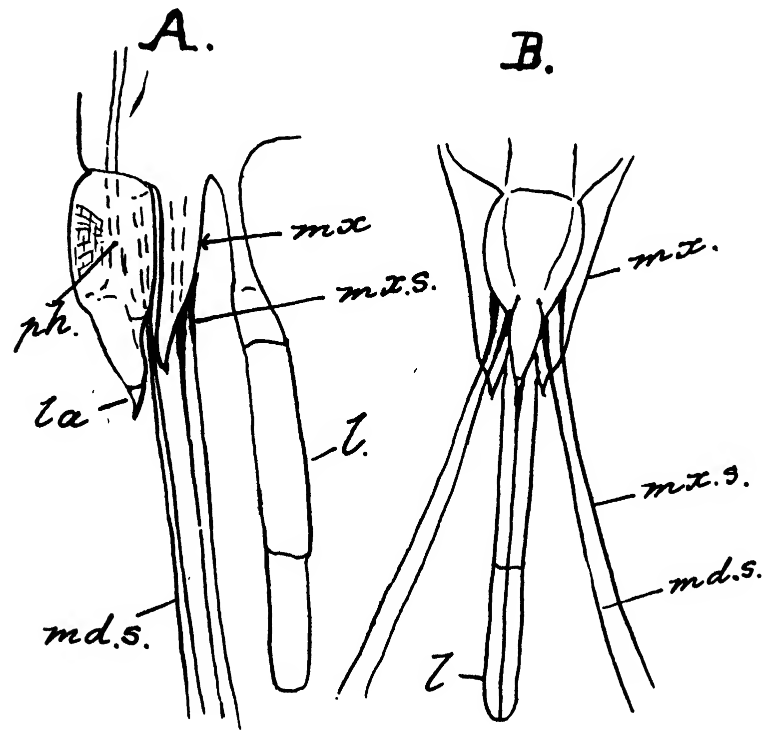
First there is the upper lip or labrum (la) which closes the mouth above; this consists of a flap without any appendages. Below there is a lower lip or labium (l) which is a complex organ and generally consists of two or three parts and bears a pair of jointed appendages, the labial palpi (lp); this closes the mouth below. On each side of the upper lip there is a strong mandible or gnawing organ (md); these are worked laterally by strong muscles and serve to cut and masticate the food. Between these mandibles and the lower lip is a pair of maxillae (mx); these are complex organs formed of several parts and carry a jointed palpus (mx.p.) and serve to hold the food and pass it into the mouth. Inside the mouth there is a small tongue or hypopharynx (h).

Grasshoppers, crickets, roaches, beetles, and the caterpillars of butterflies all have mouth parts of this type and they bite and chew their food. The nature of the damage done by this type is seen in the destruction of the leaf by army worms and the rose beetles, and of the stalk of the sugar cane by the sugar cane beetle borers.

Wasps have a slight modification of this type and bees a still greater modi-

fication, the tongue being often greatly developed for lapping. Flies have still greater modifications, some for piercing and sucking, such as a mosquito, and others for sucking, as in the house fly.

In the Hemiptera, to which the sugar cane leafhopper belongs, the modification is very great, although the parts found in the mandibular type are all present (Fig. 2). The labrum or upper lip (la) is small. The lower lip or



(A) Side and (B) front views of mouth parts of a leafhopper.

labium (l) is long, jointed, and deeply grooved down the middle of the upper surface, the edges of the groove meeting together thus forming a tube. Each mandible consists of a long, slender seta (md.s.) and each maxilla is formed of a plate (mx) and a long, slender seta (mx.s.). If viewed under a high-power microscope these four setae are seen to be fitted with a beautifully adapted tongue and groove along the greater part of their length. By this means they all fit together and form a complete slender tube, the four parts of which can move independently in a longitudinal direction without destroying the tube. The tips of the setae are sharp and the tips of the mandibles are barbed so that they are able to "saw" into the tissues of the cane plant, even into the hard rind. The labium forms a cover for the setae when at rest, and as a guide as the setae are driven into the plant; its tip also serves as a sense organ to understand the nature of the surface it is about to pierce. Just inside the mouth is the pharynx (ph) or entrance to the throat. This is formed of two plates curved up at the sides where they are attached to the wall of the head. Posteriorly the pharynx continues as the gullet into the stomach; anteriorly the upper plate of the pharynx joins the inner wall of the labrum and the lower plate joins the base of the tongue. Muscles are attached to the upper plate of the pharynx and the wall of the head, and by their contraction the upper plate moves away from the lower, thus causing

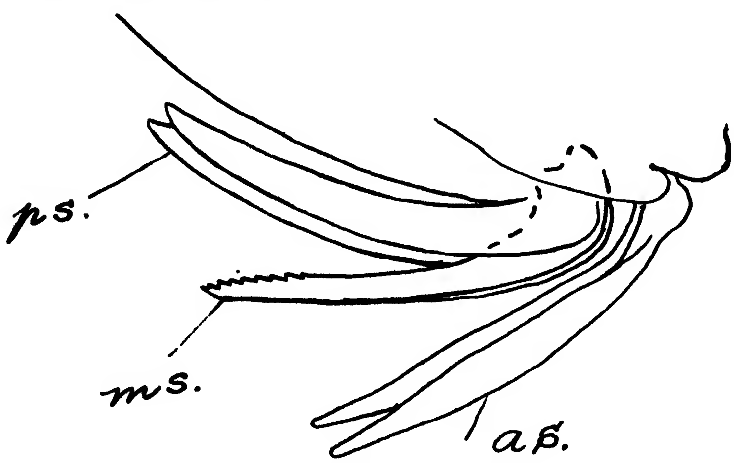
a vacuum, and a suction pump is thus formed. By this means the juices of the plant cells, in which lies the tip of the tube formed by the setae, are sucked up into the pharynx and swallowed, like ice cream soda through a straw.

We thus see that the leafhopper is incapable of biting the leaf or stalk of the cane, but can only make minute punctures through which they drain away the juices of the plant. The amount of juice that passes through the intestines of a leafhopper is very great. This may be necessary to enable them to get enough nutriment out of such a liquid food. The juices pass out of the anus as small, round globules on to a small appendage beneath the anus and is flicked off by the movement of this appendage and falls on the leaves.

In Trinidad it has been estimated that the froghopper on the sugar cane extracts and voids one-half drachm of clear liquid in one hour. Estimating fifty froghoppers to a stool and eight hours at night as their feeding time, would make about one and quarter pints of sap extracted every twenty-four hours. Our leafhopper is much smaller in bulk but more numerous, and when very numerous their extraction is likely to be higher than that. There is no indication that the leafhopper conveys diseases to the cane or injects toxin into the plant, as is probable with the froghopper of Trinidad.

The liquid extracted is called "honey dew." It spreads over the leaves and gives them a sticky surface over which a black fungus soon grows. It is this blackening of the leaves which often gives the first indication that hoppers are numerous in a field, and when found dried up on older leaves indicates that hoppers have been numerous in the field at an earlier date. This blackening of the upper surface of the leaves cannot be considered as harmful in itself, or looked upon as a cause of the stunting or death of the cane.

The two sexes of the insect can easily be recognized by an examination of the underside of the abdomen. In the female there is a brown, slender organ proceeding from near the base of the abdomen to the pointed apex. This is the ovipositor or egg-laying organ In the male there is no such organ and the apex of the abdomen is not pointed but cut off straight, and the end forms a harder ring than the rest of the abdomen.



Ovipositor of leafhopper.

If we examine the ovipositor (Fig. 3) we find that it is made up of five separate pieces, two pairs and a single piece. The posterior pair (ps) is larger

than the others, slightly concave on the inner surface and forms a cover for the others. The middle organ (ms) is originally formed from a pair joined together along their posterior edge, thus forming a deep groove along their anterior surface; this organ is the active portion of the ovipositor, is harder, pointed at its apex, and toothed like a saw for some distance along its apical posterior surface. The anterior pair (as) is fastened by a tongue and groove process to the median organ so that they work as one organ and form a channel along which the egg passes into the cut made by the ovipositor.

By the aid of this organ the insect cuts into the tissue of the plant, either in the midrib of the cane leaf, which is its favorite locality, or into the thinner blade of the leaf or into the stalk of the cane. Into the hole thus cut it passes from one to seven eggs, or even more. The tops of the eggs project slightly beyond the hole and are covered with wax secreted by the female. This wax forms a protection against moisture even if it does not protect them from parasites. The small, white masses show up against the green leaf and stalk.

The wounds made by the egg punctures do not appear to do much injury to the cane. It is possible that they may give entrance to fungus spores, but this appears to be quite a minor cause of damage.

A female is estimated to lay about 75 to 100 eggs. These take from fifteen to forty days to hatch out, according to the temperature, an increase shortening the time and a decrease lengthening it.

The young upon hatching are like the adults in the arrangement of their mouth parts and their method of feeding, but they possess no wings or ovipositor, and have only two joints to their feet instead of three. They feed and grow larger and cast their skin four times before they become adults; the wing pads increase in size at each moult.

There are two forms of the adult, the long wing form in which the front wings reach considerably beyond the body, the hind wings are large and the insect is capable of flight; and the short wing form in which the front wings do not reach beyond the end of the body, the hind wings are absent or very small and the insect is incapable of flight. The short winged forms are found only, or mainly, during the cooler months of the year.

The time occupied in development from birth to adult varies with the temperature, but runs from around twenty to seventy days. The length of adult life in a state of nature is difficult to estimate, but is somewhere around sixty days.

The insect becomes active about dusk or just after sunset, when they rise on the wing and move about. Mating takes place at night.

The species of leafhopper we have in Hawaii (*Perkinsiella saccharicida*) is found in Java and Australia, but has not yet been found in any of the intervening islands. If it be a native of both of these localities we should expect to find it in some of these islands, but if it has been introduced into Australia with sugar cane from Java it is quite likely not to exist in them. It is found in Formosa, where it may have been introduced from Hawaii or Java with cane cuttings. I took one specimen in Fiji, where it may have been introduced from Australia or Hawaii. Hawaii received it from Australia in cane cuttings some eighteen or nineteen years ago.

At present twenty-three species of the genus are known, with the following distribution:

1. *P. saccharicida*—Java, Australia, Federated Malay States, Formosa, Hawaii, Fiji (one specimen).
2. *P. vastatrix*—Java, West Borneo, Amboina, Ceram, Papua, Philippines, Federated Malay States, (East Africa?)
3. *P. graminicida*—Australia.
4. *P. vitiensis*—Fiji, Savage Island or Niue.
5. *P. papuensis*—Papua.
6. *P. bicoloris*—Papua.
7. *P. lalokensis*—Papua.
8. *P. amboinensis*—Amboina.
9. *P. variegata*—Papua.
10. *P. rattlei*—Papua.
11. *P. pallidula*—Borneo.
12. *P. manilae*—Philippine Islands.
13. *P. fuscipennis*—Philippine Islands.
14. *P. lineata*—Philippine Islands.
15. *P. saccharivora*—Philippine Islands.
16. *P. pseudosinensis*—Philippine Islands.
17. *P. manilae*—Philippine Islands.
18. *P. bakeri*—Philippine Islands.
19. *P. sinensis*—China, West Borneo, Japan.
20. *P. thompsoni*—Guam, Java.
21. *P. insignis*—India.
22. *P. facilis*—India.
23. Species unidentified, near *P. bakeri*—West Africa.

We thus see that it is scattered over the whole of the tropical old world, but it is not found in the new world.

Leafhopper Parasites.[1]

There are a number of methods employed to combat insect pests. For the sake of convenience they are generally divided into two classes, artificial and natural.

Under artificial are included such methods as insecticides, repellants, traps, baits, catchers and protectors. Others which are generally spoken of as artificial, but which might well be called natural, are resistant varieties of the host, change or rotation of crop, and agricultural methods such as clean culture, late or early planting. Under natural methods are included all natural enemies such as animals and plants. But the artificial introduction of an enemy from one region to another might well be included under artificial. The division does not bear criticism, but it is convenient and generally understood.

When the leafhopper was first recognized as a serious pest to the sugar industry in Hawaii considerable discussion ensued as to which method would be best to employ, and various artificial methods were tried. But it soon became

[1] I use this term in a general sense to include all natural enemies.

evident that owing to local conditions and the nature of the crop, no artificial method then known would adequately cope with the situation.

This decision having been reached, Messrs. Koebele and Perkins proceeded to Fiji and Australia to study the leafhopper in those countries with the object of introducing such parasites as they found doing effective work on *Perkinsiella.* The result of their work was the introduction of several parasites, which were so successful that in a short period after their introduction the whole problem was changed. On over ninety per cent of the cane area of the islands the leafhopper was controlled to such an extent that no practical damage was done; over the remaining ten per cent of the area the leafhopper was but partially controlled so that local outbreaks occurred, causing more or less damage.

Since then the genus *Perkinsiella* has been studied in various countries bordering the Pacific, and a close study made of the various factors keeping the different species in check. It has been shown by this study that similar factors are at work in all of these localities, and it is due to them that no loss occurs in such sugar growing countries as Fiji, Australia, Java, Philippines and Formosa.

Efforts have been made to introduce into Hawaii still more of the factors working in these regions, but owing to certain biological conditions this has so far only been partially successful.

In each of the areas in which *Perkinsiella* has been studied it has been found that a certain number of primary insect parasites preyed upon the leafhopper; a number of other secondary parasites affected it indirectly by attacking the primaries; tertiary parasites sometimes attack the secondaries. The problem is again complicated by some of the primaries attacking one another. Fungus parasites sometimes attack the central host and also the secondaries and tertiaries. Mongoose, rats, birds, lizards, and frogs also play their part in this association, which is known as the biological complex for the insect studied. Even such a biological complex is not independent, but works in the orbits of other biological complexes. The same species may pertain to two or more complexes, and as their food increases or decreases in one complex, so will their effect upon the others alter.

The interaction of the species forming a complex, and of the various complexes which make up a fauna of a given area are difficult to follow. They are affected by the seasons and the weather conditions.

The reason why we have had such quick and pronounced success in Hawaii with some of our introduced parasites is because of the limited nature of our native fauna and flora, which consequently makes our associations of complexes much more simple than is generally found in continental areas. But our individual complexes are not always so simple as is believed, and the biological complex drawn up for *Perkinsiella saccharicida* in the Hawaiian islands, although incomplete, shows forty-one insects which act and interact upon one another to the advantage or disadvantage of the central host.

Complexes have been drawn up for insect pests in various parts of the world. and deductions have been made from them. In certain cases the complexity of the association has been brought forward as a reason against the introduction of parasites. It is maintained that the introduction of a single parasite into such a complex problem can have very little effect upon the ultimate results.

This conclusion is fallacious. We are not confined to introducing only one parasite if we can find more; and a single introduced parasite may entirely alter the whole complex so far as the status of the central host is concerned. In the case of the *Perkinsiella* complex in Hawaii *Paranagrus* forms the keystone of the whole problem. Withdraw that factor and the whole of the remainder as they stand today would not be able to hold the leafhopper in check.

The list below shows that the *Perkinsiella* complex is as complicated as that of the froghopper in Trinidad, which has been cited as a case where introduced parasites could not succeed.

Those who insist that parasitic work is only feasible in small, oceanic islands, entirely overlook the great *Vedalia* classic. This little ladybug was successfully introduced into California to check *Iceria purchasi;* later it was introduced into Portugal, Egypt, Capetown, New Orleans, and elsewhere with equal success. These are all rich continental areas.

By a greater knowledge of biological complexes in the future it is possible that we may be able to attack a pest not directly by introducing primary parasites, but by reducing some of the secondary.

List of Primary, Secondary, and Tertiary Parasites.

Diagram I.

1. *Paranagrus obtablis* Perks.

This is a minute wasp of the family Mymaridae. It lays its eggs in the eggs of the leafhopper, upon the contents of which the grub feeds. It undergoes its metamorphosis within the eggshell of the host, eventually emerging as a mature insect through a small hole which it gnaws. As the length of the life cycle of *Paranagrus* is about four weeks, and that of *Perkinsiella* about ten, the parasite can have two and a half generations to one of the host. This makes it a very efficient parasite if other factors are not favorable. As will be seen below it is affected by both the *Ootetrastichus* and *Cyrtorhinus,* and it is attacked by Lacewings, *Xiphidium* and Earwigs. Being such a minute, delicate insect it is affected by weather conditions, especially by rains. In spite of all these it is by far the most important of the parasites on *Perkinsiella* and without it all the rest of them could not hold the hopper in check under present conditions. We can call it the keystone parasite.

This insect was introduced from Australia by Koebele and Perkins in 1905.

2. *Anagrus frequens* Perk.

This insect is similar to *Paranagrus* in its life cycle, and is closely related to it. It is not nearly so numerous and does not play such an important part in the complex. It was introduced from Australia by Koebele and Perkins.

3. *Ootetrastichus beatus* Perk.
4. *Ootetrastichus formosana* Timb.

These two species of parasitic wasps are larger than the two mentioned above and their size brings about a somewhat different habit. After having devoured the contents of one egg, which is not sufficient food to carry the larva to maturity, it attacks the other eggs in the cluster and devours them all. It

PARASITE COMPLEX OF PERKINSIELLA SACCHARICIDA IN HAWAII.

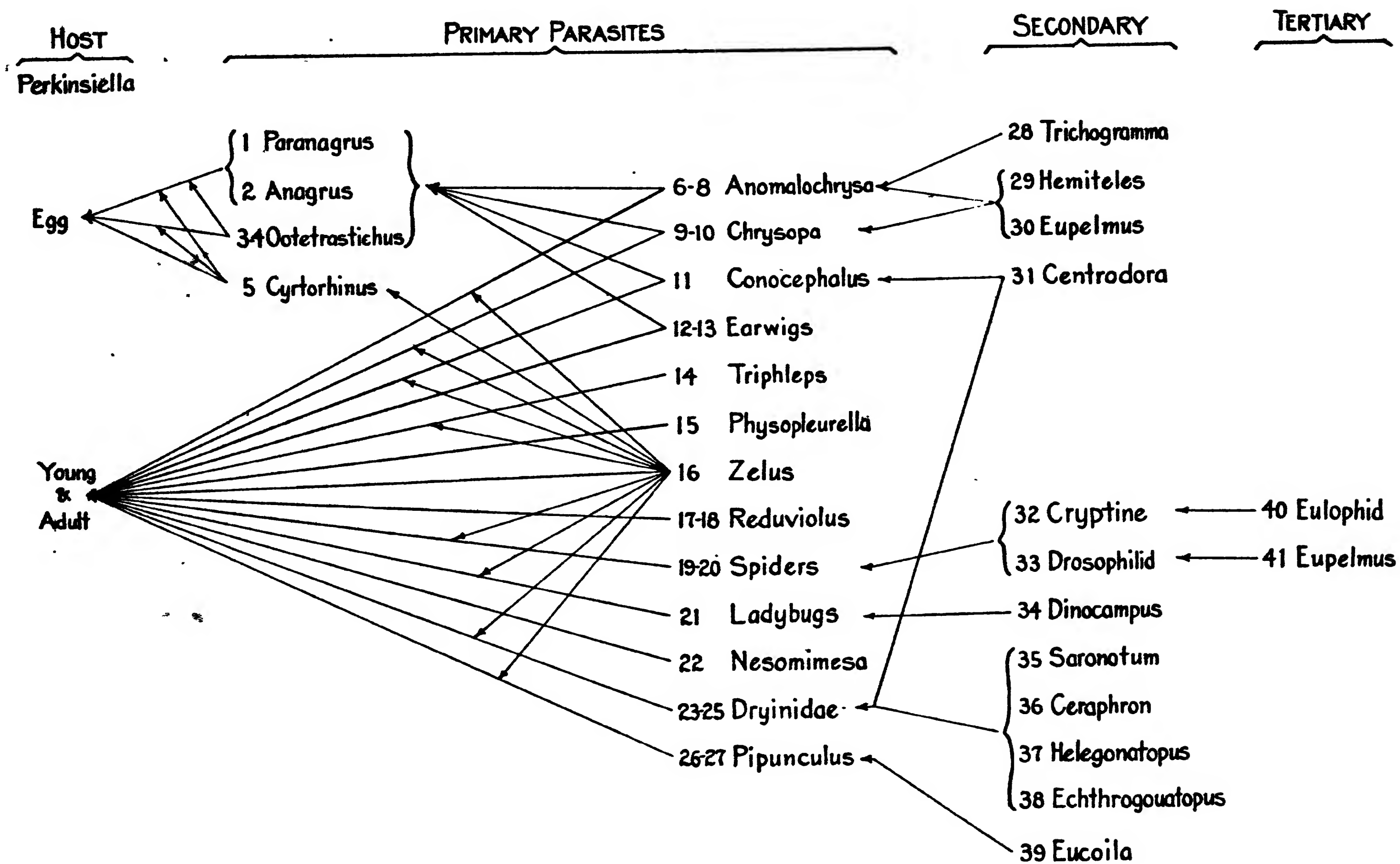


DIAGRAM I.

then turns to a pupa within the egg cavity and the adult eventually gnaws a round hole through which it passes to the open. It takes about six weeks for its life cycle. As it attacks hoppers' eggs which have been parasitized by *Paranagrus* and *Anagrus* as well as those which have not been parasitized, its effect upon these two parasites must be considered. *O. beatus* Perk. was introduced from Fiji by Koebele, and *O. formosana* from Formosa. It was hoped that the latter, coming from a cooler locality than the former, might work better in some of the higher lands.

5. *Cyrtorhinus mundulus* (Bred.).

This insect belongs to the same Order as the leafhopper, the Hemiptera, and its mouth parts are built on the same plan and function in the same way. Instead of feeding upon the juices of plants, as the leafhopper does, it appears to confine itself to the contents of the leafhoppers' eggs, which it pierces with its slender setae and sucks.

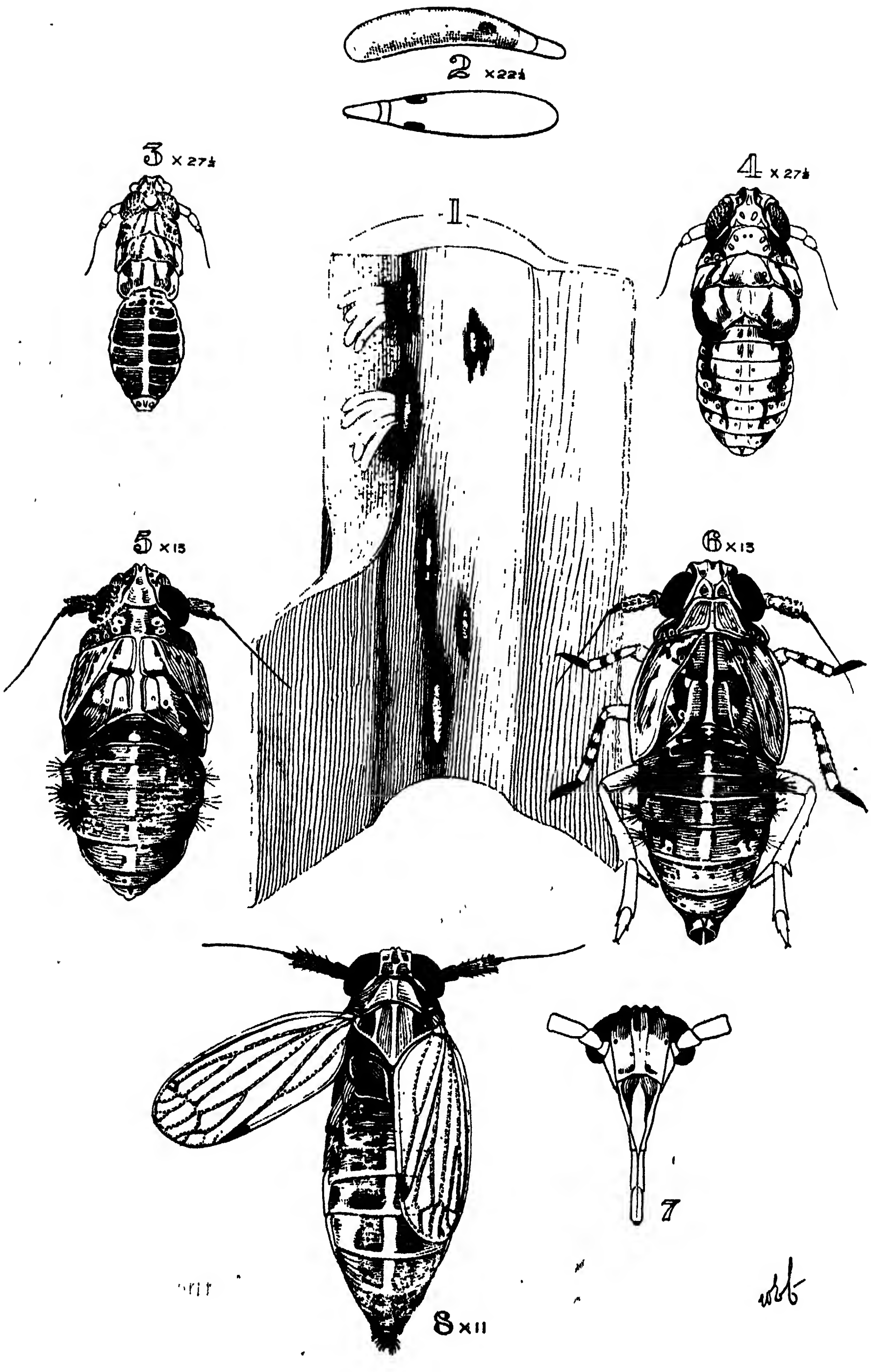
It was introduced from Australia and Fiji, in which countries it plays a very important role in the complex. It is hoped that it will play a similar part in Hawaii in those localities where climatic conditions are not most favorable for *Paranagrus*. It is established in certain localities in Oahu and Hawaii, but it has not increased or spread in a satisfactory manner. Observations indicate that some factors are keeping it down. So far we have only found *Zelus* attacking it, but as the young of *Zelus* and *Cyrtorhinus* congregate together in the same localities on the sugar cane and the former prey upon the latter, and are often numerous, it is possible that *Zelus* is the chief or only limiting factor.

Zelus has no parasites in Hawaii and it would be an interesting experiment to introduce some from California if they can be found.

Lacewings.

6. *Anomalochrysa deceptor* Perk.
7. *A. raphidioides* Perk.
8. *A. gayi* Perk.
9. *Chrysopa microphya* McLachl.
10. *Chrysopa* op.

These five neuropteroid insects belong to the Lacewinged flies. Their larvae are predacious and feed chiefly upon plant-lice, but other small insects, including young hoppers, do not come amiss to them. The mandibles are sickle-shape and grooved. They grasp their victim with these mandibles and suck them dry. The larvae of the *Anomalochrysa* run over the cane leaves without protection, but the *Chrysopa* covers itself with foreign matter, including the skins of its victims. They take such small fry as *Anagrus* and *Paranagrus* and so counteract their direct attack upon the young hopper to some extent. *Anomalochrysa* and *Chrysopa microphya* are native insects, but the other species of *Chrysopa* is a comparatively recent immigrant, which has not yet been identified. These are parasitized by three small wasps: *Trichogramma* sp. (28) on the eggs and *Hemiteles tenellus* (29) and *Eupelmus* sp. (30) on the cocoons.



(1) Section of cane leaf showing egg punctures and eggs. (2) Eggs greatly magnified, the dark mark being the eyes of the developing embryo. (3) First stage of nymph or young. (4) Second stage ditto. (5) Third stage ditto. (6) Fourth stage ditto. (7) Face of same. (8) Adult short winged female.

11. *Conocephalus saltator* (Sauss.).

This large "longhorned grasshopper" is abundant in pasture lands, grass along roads, and in cane fields when not kept clear of weeds and grasses. Both young and old devour young and adult hoppers and they play an important part in the hopper complex. The young *Conocephalus,* and even the adults, devour the egg parasites (1–4) and from that point of view partly counterbalance their direct attacks on the hopper. But the sum of their work appears to be beneficial and their presence should be encouraged in the cane fields. A parasite attacks their eggs *(Centrodora xiphidii* No. 31) and *Zelus* and spiders also take their toll.

This is a native of Central America and found its way into the islands some thirty years ago. It is described and figures under the name of *Xiphidium varipenne* in Bulletin I, part 7.

Earwigs.

12. *Anisolabis annulipes.*
13. *Chelisoches morio.*

There are several earwigs found in our cane fields, but the above mentioned two are the most common and of greatest economic importance.

They feed upon both young and adult leafhoppers and so are of economic importance in keeping down their numbers. But *Chelisoches morio* has been shown to destroy a great number of egg parasites, and so it counterbalances the good it does. I have seen *Zelus* attacking them at times.

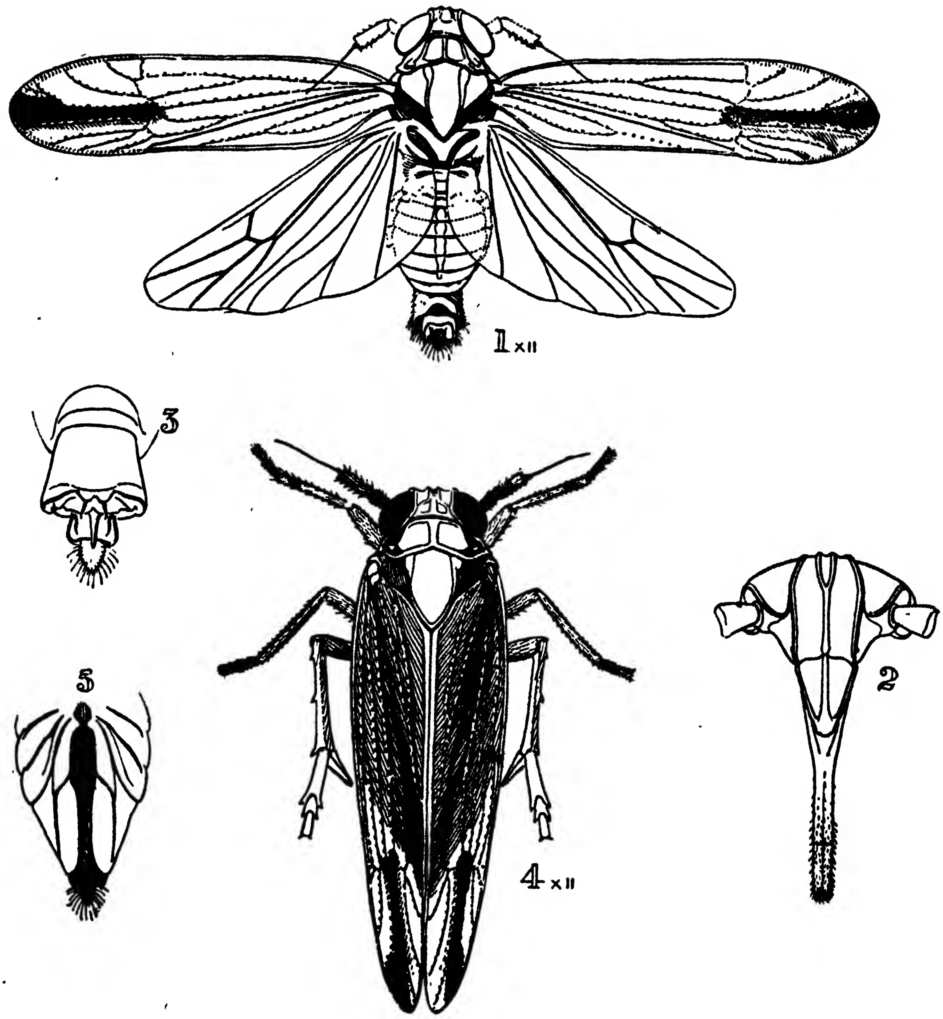
These are both foreign insects which have become established in our Islands.

Hemiptera.

14. *Triphleps persequens.*
15. *Physopleurella mundulus.*
16. *Zelus renardii.*
17. *Reduviolus blackburni.*
18. *Reduviolus capsiformis.*

These five insects all belong to the same order as the sugar cane leafhopper and *Cyrtorhinus,* the Hemiptera, and have the mouth parts constructed upon the same plan and functioning in a similar manner. They are predacious and feed upon the leafhopper.

Zelus renardii is by far the most abundant and important economically and plays a conspicuous part in the leafhopper complex, for not only does it attack the leafhopper in the adult and young stages, but it attacks most of the other direct enemies. Taken altogether its effect upon the cane is considered as being more harmful than beneficial. It is considered the chief factor in checking the increase and spread of *Cyrtorhinus;* it has a decided effect upon the number of ladybugs in the cane fields and is an enemy of *Chrysopa.* It is a Californian insect that found its way into the island some twenty-five to thirty years ago. It has spread all over the islands and is very numerous in cane fields, especially where leafhoppers are abundant. It has been figured and described under the name of ***Zelus peregrinus*** in Entomological Bulletin No. 1, part 7.



(1) Adult male. (2) Face of same. (3) Apex of abdomen of same. (4) Adult long winged female. (5) Ventral view of abdomen of female showing ovipositor.

Spiders.

19. *Pagiopalus atomarius.*
20. *Tetragnatha mandibulata.*

Some twenty species of spiders are found in the cane fields, but only two can be considered as economically important. *Pagiopalus* is one of the hunting spiders and does not build a web, and is the more important of the two. Their presence in cane fields where leafhoppers are numerous is generally made evident by their egg cases attached to the cane leaf, as many as fifty having been counted on a single leaf. That they prey upon other insects of the complex is true, but their result I consider as beneficial.

There are several parasites on the spiders in Hawaii. Several species of hunting wasp, a Cryptine wasp (32) and a fly (33). The cryptine wasp is parasitized by an Eulophid (40) and the fly (Drophilidae) by an *Eupelmus* (41). The spiders found in our cane fields are figured and described in Entomological Circular No. 7.

Ladybugs.

21. *Coelophora inaequalis.*

There are several ladybugs in the cane fields, but only one that plays much part in the leafhopper complex. This is figured and described under the name of *Coccinella repanda* in Entomological Bulletin No. 1, part 7. It feeds upon Aphis and leafhoppers, more especially on young hoppers. It is preyed upon by a wasp (*Dinocampus terminatus* 34), and is attacked in both the larvae and adult stages by *Zelus.*

Hunting Wasps.

22. *Nesomimesa hawaiiensis*

This wasp burrows into the soil and makes a number of little chambers which she stocks with leafhoppers, and therein places her eggs. It has a very restricted range. It is fully described and figured in The Record for September, 1918, page 175. It plays but a minor part in the complex.

This is a native insect which has transferred its attention from native hoppers to *Perkinsiella.*

Dryinidae.

23. *Echthrodelphax fairchildii.*
24. *Haplogonatopus vitiensis.*
25. *Pseudogonatopus hospes.*

The females of these ant-like wasps are often wingless and then they look even more ant-like than the winged forms. Their front legs are developed into pinchers somewhat like a crab's. By the means of these pincher-like claws they catch and hold the leafhopper while they lay an egg in it. The young parasite comes out and attaches itself to its host and develops, the old skins remaining on and looking like a small dark sack. By the time the parasite is full fed the young hopper is sucked dry and dies.

These parasites are preyed upon by five other parasites, *Centrodora xiphidii* (31), that also attacks the eggs of *Xiphidium; Serenotum americanum* (35), *Cerephron abnormis* (36), *Helegonatopus pseudophanes* (37), and *Ethro-*

gonatopus sp.(38). Of these *S. americanum* is by far the most effective in keeping down the Dryinidae. In fact were it not for these secondary parasites I belive that these Dryinidae would be so effective that we should have no trouble whatever with leafhopper. Here is an instance where to relieve a parasite of its enemy might do more good than introducing a new parasite.

Echthrodelphax was first described from these islands and may be a native insect, or it may be an immigrant from some place at present unknown; the other two species were introduced, one from Fiji and the other from China.

26. *Pipunculus juvator.*

27. *Pipunculus hawaiiensis.*

These are two native flies which have taken to attacking the same leafhopper. Their habits are fully described and one figured in The Record for September, 1918, page 189. They search for the hoppers, which they pounce upon and carry into the air, holding them by means of their large claws. By the means of a sharp ovipositor an egg is laid in the body of the hopper and then the hopper is released. The parasite develops inside the host at the expense of the juices of the hopper, and when it is fully grown the hopper is killed and the parasite emerges to pupate.

Even in the interior of the body of the hopper this fly grub is not concealed from its enemies, for a small wasp (*Eucoila* sp. 39) manages to parasitize it.

Ants.

Pheidole megacephala is abundant in most of the cane fields and has a decided effect upon all insect life found there. If included in the diagram it would have to be indicated as attacking nearly every insect mentioned, as there is little that it will not take if it has the opportunity.

Fungus.

Metarrhizium anisopliae.

Entomophthora sp.

Sporotrichium sp.

Cordyceps.

The green mascardine fungus (*Metarrhizium anisoplioe*) is common on many insects in the islands, especially on beetles, and plays a part in the complex. But it is the other three species that are the more important, as they are all directly parasitic on the leafhopper. In certain areas in certain seasons, when the conditions are favorable, one or more of these become very common, and at times appear to wipe out the leafhopper over an area. For this reason they play an important direct part in the complex. At times when its infestation is very great it is possible that it may eventually lead to an increase of hoppers. If a severe epidemic carries off all the adults and young hoppers, leaving only the eggs (some of which will be parasitized and some not), then no more eggs will be laid till the young hatch out and grow to maturity, a period of some forty to fifty days. During a period of about three or four weeks the egg parasites will hatch out, but finding no eggs to oviposit in will die, thus leaving the next generation comparatively free from egg parasites. This may appear far fetched and theoretical, but observations indicate that such a thing may occur and probably does at times.

Vertebrate Enemies.

Mongoose, rats, lizards, frogs, and birds all play a part within the complex. Mynahs are the most numerous of the birds in our cane fields and take a toll of most of the larger insects found there, *Concocephalus* being an appreciated food.

Mynahs are preyed upon by both rats and mongoose, and the mongoose also preys upon the rats as well as lizards and frogs. Lizards and frogs are scarce in our cane fields, and so play but a small part in the complex.

Weather.

Affecting all the above mentioned factors is the weather. Increase of heat shortens the life cycle of most of the insects and decrease lengthens it. As all the insects are not affected proportionately, this leads to an alteration in the complex.

Rains are inimical to such delicate parasites as *Paranagrus* and *Anagrus* (the former being the most important parasite in the complex), and so they play a most important part in the complex. Moisture is an important factor in the development of fungus and thus plays an important part. Prevailing winds will gradually drift hoppers in one direction, and should they be drifted into sheltered fields, are liable to accumulate there and breed, thus being constant spots for leafhopper outbreaks.

Thus we see that the biological complex that has gathered around *Perkinsiella saccharicida* since it arrived in the islands some nineteen years ago is as great as is known to be round insects in their own habitats in continental areas. The greater the individual complex, the greater the difficulty may be in introducing and establishing an efficient insect parasite. But this does not make the task impossible. A more important point in this work is often the interplay between the different individual complexes that make up the fauna of a region.

The Effect of Cush Cush on Clarification.

By H. F. Bomonti and Will R. McAllep.

Developments in milling work have resulted in finer grinding of the cane, and this has been accompanied by an increase in the amount of cush cush that passes the mill screens and finds its way into the mixed juice. This is particularly true where shredders are used. The object of this investigation was to determine the effect of this cush cush that remains in the mixed juice on the increase in purity that can be obtained during clarification.

It was pointed out in the 1920 Annual Synopsis of Mill Data: "This year, however, the press cake per 100 cane has increased from 2.32 to 2.62 per cent, a very considerable increase. * * * There seems, however, to be some connection between the increased amount of press cake and the smaller increase in purity compared with last year. Twelve out of eighteen factories reporting a larger amount of press cake, report a smaller increase in purity compared with last year, while eleven out of nineteen factories reporting less press cake, report a greater increase in purity."

H. S. Walker, in a contribution to the Report of the Committee on Manufacture of Sugar and Utilization of By-Products, H. S. P. A., 1920, says: "It seems very probable that the action of heat and lime may extract from the bagacillo gums and other substances which are not conducive to the best results in the boiling house." Mr. S. S. Peck, in the same report, states: "It was found when fine trash was present during the clarifications, there was a very decided increase in the amount of soluble gums present, over tests where this was removed, and the less the acidity, the greater was the solvent action."

This is a subject which has apparently received but little attention, for no published references to it other than the above were found.

The following preliminary experiments were made:

A portion of mixed juice from H 109 cane from Oahu Sugar Company was limed with 6 cc. milk of lime per liter, brought to a boil and allowed to settle on a steam bath for an hour and a half. A second portion was passed through a 100-mesh screen, removing all but the finest of the suspended matter. Both portions were then filtered with kieselguhr and through hardened filter paper and analyzed.

The results are given in Table 1.

TABLE 1.

	Reaction (Equivalent to % CaO)	Purity		Effect of Cush Cush
		Screened Juice	Unscreened Juice	
Before Clarification ...	0.011 acid	80.	62	
After Clarification	0.008 alk.	82.44	82.04	0.40

Mixed juice from H 109 cane from Honolulu Plantation Company was next tried. From one portion all suspended matter was removed by filtration through kieselguhr and hardened filter paper. Portions of both the unfiltered and filtered juices were then limed with 1, 3, 5 and 7 cc. milk of lime and treated as before. The results follow:

TABLE 2.

	Filtered		Unfiltered		Effect of Cush Cush
	Reaction	Purity	Reaction	Purity	
Mixed juice ..	0.006 acid	88.49	0.006 acid	87.11	
1 cc lime	0.002 alk.	89.46	0.002 alk.	88.53	0.93
3 cc lime	0.010 alk.	89.03	0.012 alk.	88.57	0.46
5 cc lime	0.014 alk.	90.16	0.016 alk.	89.56	0.60
7 cc lime	0.018 alk.	90.70	0.018 alk.	89.75	0.95

A similar series of Lahaina juice from Honolulu Plantation Company gave results agreeing closely with the above.

The above results indicate that the presence of cush cush diminishes the increase in purity that can be obtained in clarification.

These preliminary experiments bring up the following points for further investigation:

First: The cause of the irregularities in the differences shown above.

Second: Whether the filtration through kieselguhr influenced the results.

Third: Whether the differences will increase with increasing amounts of cush cush in the juice.

Fourth: Whether the differences are due to the action of lime and heat on the finely divided material or o the presence of lower purity juice in the cush cush.

With respect to the first point, polarization was determined by Horne's dry lead method. When sucrose determinations were made, Walker's inversion method was used. With reasonable precautions these methods are sufficiently accurate so that unavoidable errors have but slight effect on the purity coefficient. Brix determinations, however, were made with a hydrometer and readings accurate to more than 0.05 degrees can hardly be expected. Most of the juices worked with were between 11 and 14 brix. An error of 0.05 in the brix determination affects the purity of such juice to the extent of some 0.4 degrees; almost a half of the maximum difference noted above. When juices are filtered the brix can be determined with a much greater degree of accuracy with a pycnometer, so in order to more accurately estimate the comparatively small differences in purity found, the brix of all filtered juice in the work subsequent to that reported in Table 3 was made with this instrument.

The clarified juices were filtered with kieselguhr, because the differences in purity with which we are dealing are comparatively small. Kieselghur filtrations completely removes suspended solids and makes practicable a considerably greater degree of accuracy in analyses than would otherwise be the case.

In mixed juice, we have found that it gives apparent increases in purity of

from 0.4 to 1.4, the difference being due to the effect of the suspended solids and colloidal matter on the brix of the unfiltered juice. An example of this is shown in Table 2, where the increase in purity is 1.38.

In well settled clarified juice the difference is much smaller and rarely amounts to 0.2. Kieselghur does not remove solids from solution, and as the check samples and those to which cush cush was added were both filtered with it; this treatment should not influence the comparisons made in this investigation. That this is the case may be seen by an inspection of Table 5. One series in this experiment was filtered through filter paper and a corresponding series with kieselghur. The juices filtered with kieselghur were limpid. Those filtered through filter paper were slightly turbid and of a lighter tint. While the former are slightly higher in purity, averaging 0.12, the figures for the effect of the cush cush are in both cases practically identical.

Several experiments were made to determine whether the effect of cush cush on the purity was in proportion to the amount of cush cush added.

In a sample of mixed puice from H 109 cane from Honolulu Plantation Company the greater part of the cush cush was removed by passing the juice through a 100 mesh screen. The juice was then limed to a suitable point and to liter portions of this juice, weighed amounts of the cush cush were added. This cush cush had been subjected to a pressure of about 1000 lbs. per sq. in., reducing it to a moisture content of about 60%. The juices were then boiled, allowed to settle for an hour and a half on a steam bath, filtered with kieselghur and analyzed. The reaction of the juice is expressed as equivalent to per cent CaO, referred to litmus as an indicator.

The results follow:

TABLE 3.

Treatment	Reaction = % CaO	Gravity Purity	Effect of Cush Cush
Untreated	0.008 acid	84.66	
6 cc. lime	0.012 alk.	87.78	
6 cc. lime + 10 gm. cush cush	0.012 alk.	86.67	1.11
6 cc. lime + 20 gm. cush cush	0.012 alk.	86.98	0.80
6 cc. lime + 25 gm. cush cush	0.012 alk.	85.95	1.83
6 cc. lime + 30 gm. cush cush	0.012 alk.	86.73	1.05

In the above experiment a very much smaller increase in purity was obtained in samples containing cush cush than was obtained in the check. No definite relation is shown between the differences in purity and the amount of cush cush present. This is not necessarily conclusive, however, as the brix determinations were made with a hydrometer and, as already noted, were subject to a comparatively large factor of error.

Juice from Lahaina cane from Honolulu Plantation Company was next treated. The general procedure was the same as the proceeding experiment, but in addition three series were run at different alkalinities. Brix determinations were made with a pycnometer. The results appear in Table 4.

TABLE 4.

Treatment	Reaction	Purity	Effect of Cush Cush
Untreated	0.006 acid	88.40	
2 cc. of lime	0.002 alk.	88.46	
2 cc. lime + 25 gm. cush cush....	0.002 alk.	87.99	0.47
2 cc. lime + 50 gm. cush cush....	0.002 alk.	88.02	0.44
4 cc. of lime	0.006 alk.	88.93	
4 cc. lime + 25 gm. cush cush....	0.006 alk.	88.67	0.26
4 cc. lime + 50 gm. cush cush....	0.006 alk.	88.05	0.88
5 cc of lime	0.010 alk.	89.83	
5 cc. lime + 25 gm. cush cush....	0.010 alk.	89.54	0.29
5 cc. lime + 50 gm. cush cush....	0.010 alk.	89.07	0.76

The differences due to the presence of cush cush are smaller in Table 4 than in Table 3. They show, however, a fairly consistent tendency to increase with increasing amounts of cush cush and with higher alkalinities.

The figures given in Table 5 are also for Lahaina cane from Honolulu Plantation Company. A comparison of the filtration of the clarified juice through kieselghur with filtration through filter paper, previously referred to, also appears in this table.

TABLE 5.

	Reaction	Filtration Through Filter Paper		Kieselguhr Filtration	
		Purity	Effect of Cush Cush	Purity	Effect of Cush Cush
Untreated juice	....	86.56	...	....	...
6 cc. lime	0.010 alk.	88.55	...	88.68	...
6 cc. lime + 10 gm. cush cush...	0.010 alk.	88.40	0.15	88.54	0.14
6 cc. lime + 25 gm. cush cush...	0.010 alk.	88.05	0.50	88.14	0.54
6 cc. lime + 50 gm. cush cush...	0.010 alk.	87.55	1.00	87.67	1.01

In the following series the question of to what extent the influence of the residual juice in the cush cush was responsible for the effect of the latter on the purity was also studied. To this end part of the cush cush was pressed to remove the surplus juice, as in the above experiments. A second portion was extracted by alternately soaking and pressing six times in a similar manner to determining fiber in cane.

The following is a typical analysis of the untreated and extracted cush cush:

	Untreated	Extracted
Fiber	22.0	27.4
Moisture	70.0	72.4
Polarization	6.2	0.09
Solids not polarization (by difference)	1.8	0.11
Residual juice purity (calculated)	77.5	45.5

Details of the following experiments were the same as the above, except that to portions of the limed juice equal weights of extracted and unextracted cush cush were added.

Data from an experiment with Lahaina juice from Honolulu Plantation are given in Table 6.

TABLE 6.

	Reaction	Unextracted Cush Cush		Extracted Cush Cush	
		Purity	Effect of Cush Cush	Purity	Effect of Cush Cush
Screened mixed juice	....	89.30	...	....	...
6 cc. lime	0.010 alk.	90.33	...	....	...
6 cc. lime + 10 gm. cush cush	0.010 "	90.14	0.19	90.18	0.15
6 cc. lime + 25 gm. cush cush	0.010 "	89.72	0.61	89.64	0.69
6 cc. lime + 40 gm. cush cush	0.010 "	89.49	0.84	89.50	0.83

Table 7 contains data from a similar experiment on H 109 cane from Oahu Sugar Company.

TABLE 7.

	Unextracted Cush Cush		Extracted Cush Cush	
	Purity	Effect of Cush Cush	Purity	Effect of Cush Cush
Screened mixed juice	80.62	...	....	...
6 cc. lime	82.43	...	....	...
6 cc. lime + 25 grams cush cush	81.56	0.87	81.52	0.91
6 cc. lime + 50 grams cush cush	81.19	1.24	81.20	1.23

All of these data confirm the indications of the preliminary experiments. In every case when juice has been limed and cush cush added to one portion, the purity of the clarified juice resulting from this portion has been lower than that of the portion to which no cush cush has been added.

The results shown in Tables 4 to 7 inclusive, the analyses in which have a greater degree of accuracy than those in the tables preceding, because the brix

was determined with a pycnometer, clearly indicate that the effect due to the cush cush increases with increasing amounts.

Data given in Tables 6 and 7 show that the effect of the cush cush is not on account of the residual juice contained in it, for cush cush practically free from such juice causes fully as great a decrease in purity as cush cush which has not been extracted.

The following is quoted from Bulletin No. 91 of the Louisiana Experiment Station by C. A. Browne and R. A. Blouin.

"A study of the hydrolytic products obtained by digesting purified bagasse with caustic soda showed cane fiber to be an exceedingly complex substance."

"The following results, calculated to 100 parts of cane fiber (protein, ash, fats, etc., excluded), give the approximate percentage of the different hydrolytic products":

Cellulose (including oxy-cellulose)	55%
Xylan	20
Arabin	4
Lignin	15
Acetic acid	6

"The cellulose obtained from the sugar resembles that obtained from corn stalks in many of its properties. The pith cellulose is very easily attacked by concentrated alkalies, and for this reason great care must be exercised in making paper stock from bagasse."

"The Pentosans, xylan and arabin, constitute the cane gums. These constituents of the fiber are easily soluble in alkalies, from which they are precipitated by alcohol as a gummy deposit. . . . . . ."

"The Lignin is obtained from cane fiber by digesting with solutions of the alkalies, to which it imparts a yellowish brown coloration."

"Acetic acid, the well known acid of vinegar, may be obtained from cane fiber by digesting with caustic alkali and then distilling with a slight excess of sulphuric acid.

"The above substances do not exist in cane fiber as a mechanical mixture, but in a state of most intimate combination, forming a very complex molecule whose exact structure is not yet understood."

In the process of paper making the finely divided material is digested with alkali to attack and render soluble part of the constituents other than cellulose. Though in making paper a fairly strong alkali is used, while in clarification of cane juice the concentration of alkali is small, nevertheless in the latter case somewhat similar reactions with the cush cush may be expected.

The following work was done to investigate this reaction under conditions somewhat approximating those existing during clarification:

The soluble matter was removed from a quantity of cush cush by thoroughly extracting with water, the excess of water removed in a press and the material dried in a thin layer in the sun. The final moisture content was 14.6%.

Analyzed by Cross & Bevan's method, this material was of the following composition, calculated to a moisture free basis:

Cellulose	56.6
Inorganic*	3.5
Non-cellulose	39.9

* Carbonate ash from which the carbon dioxide has been subtracted.

It will be noted that the cellulose content of this sample corresponds closely with that of the quoted analysis of extracted bagasse.

Of this cush cush 11.7 grams, corresponding to 10 grams of moisture free material, were added to a liter of water containing enough lime to approximate the conditions in the above clarification experiments. The mixture was boiled, digested on a steam bath for an hour and a half, and filtered. After washing with cold water and drying, it was found that 9% of the cush cush had been dissolved.

Analyzed by Cross & Bevan's method, this residue was found to have the following composition:

Cellulose	66.0%
Inorganic	3.5
Non-cellulose	30.5

This analysis shows that most of the loss in weight was due to removal of the non-cellulose.

By assuming that the material that went into solution in the above experiment was added to juice of a given composition, we can calculate what the effect would be on the purity, and so have a similar basis for comparing this with the other experiments.

Ten grams of cush cush added to the juice in the preceding experiments corresponds to adding 0.3 to 0.4% suspended solids. This is probably not far from the average amount of suspended solids in mixed juice in Hawaiian factories, and we will make the comparison on a basis of this amount. In these experiments summarized in Tables 4, 5, 6 and 7, the minimum depression of the purity per 10 grams of cush cush was 0.15, the maximum 0.35, and the average 0.22.

In the experiment when the cush cush was digested with lime water the amount present was equivalent to 1.0% suspended solids, so the result must be divided by three to bring it to the above basis. Assuming, then, that one-third of the material dissolved was added to a juice of 12.0% solids, and 83.33 purity, the solids would be increased to 12.03%. The purity would then be 83.12, a decrease of 0.21%. Quantitatively, then, the last experiment is in fair agreement with the preceding experiments on juice; that is, the amount of cush cush that went into solution approximated the quantities that must have gone into solution in the juices to affect the purities to the extent noted.

It can then be stated that if cush cush is present when juice is limed and heated, a part of it goes into solution, adding to the impurities in the juice, with the result that the increase in purity secured during the clarification is less than it would have been had no cush cush been present.

From a chemical point of view, keeping the mixed juice as free from cush cush as possible is desirable; indeed, a more thorough screening of the juice than is the usual practice would probably be profitable. Some efforts have been made along this line and the problem does not appear insoluble. In this connection we would note that the fuel value of the recovered cush cush is a considerable item.

Heavy liming of the settlings, from the same point of view, is an objectionable practice, for the greater part of the cush cush that was in the mixed juice is concentrated in these settlings and conditions are favorable for dissolving further portions of it.

While it is true that, according to the indications of the above experiments,

the depression of the purity due to the average amount of cush cush found in the juice does not appear large, a constant effect of this kind results in a loss of considerable magnitude. Taking the figures for 1920 from the Annual Synopsis and assuming that the suspended solids in the mixed juice have depressed the syrup purity 0.2, as seems fairly probable from these experiments, we can calculate that if this depression had not taken place the yield would have been increased by 0.188%. This would have amounted to over 1000 tons of sugar on the 1920 crop.

A Bedding Machine of Cane Lands.

The device here illustrated, an Avery implement, is said by its manufacturers to have been in hard service all winter in Louisiana, and with gratifying results. The machine is designed, we are told,

> "to take an old piece of cane land that has been cultivated eight or ten years and in one operation transform it into a fine seed bed in which to plant new cane. There is a large coulter in front that splits the hills and the ridge. The first pair of disks throws out the ridge and starts the furrow, the next pair does it still more, and the last thing is a big middle buster that opens up the row. The cane can then be planted in the furrow thus made or the motor cultivator will make a new trench at the top of the ridge. Some plant it one way and some another. . . . . . ."

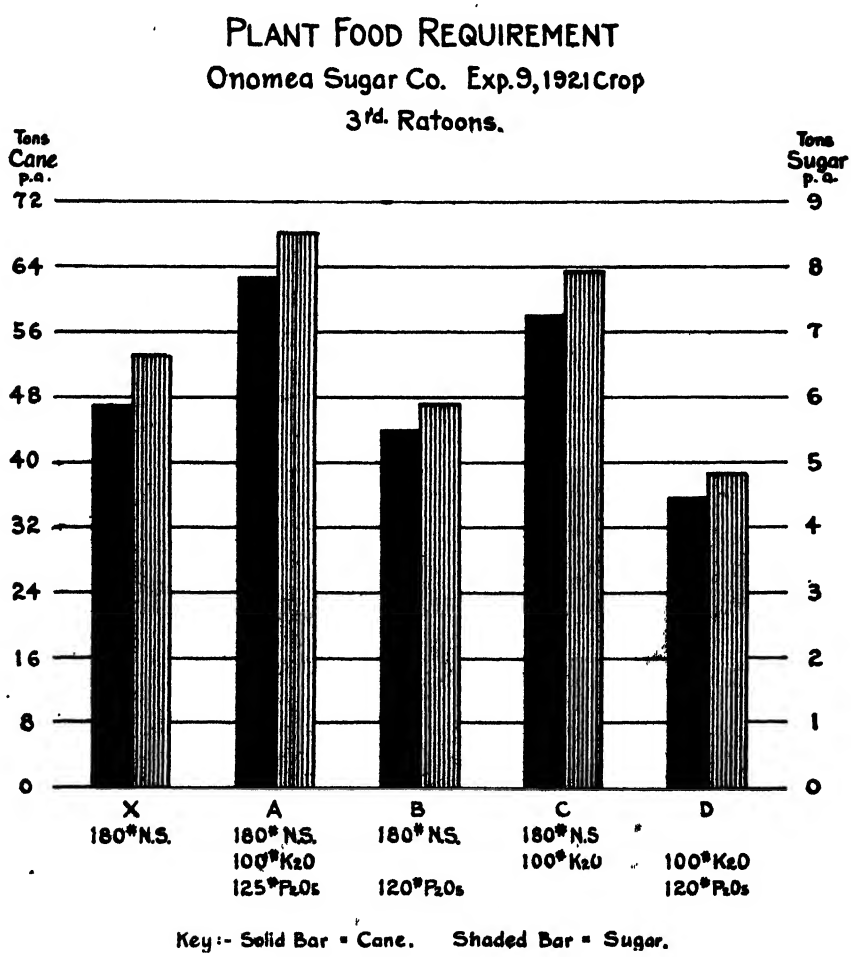
Similar implements, mostly of plantation construction, have been employed here and there in the Hilo district for destroying the heavy stools of Yellow Caledonia cane preparatory to planting operations.

Nitrogen, Phosphoric Acid and Potash in Different Combinations.

ONOMEA SUGAR COMPANY, EXPERIMENT NO. 9, 1919 AND 1921 CROP.

This was a test designed to determine the need for nitrogen, phosphoric acid, and potash by the soils of the Hilo coast.

The experiment was laid out in field No. 3 of the Onomea Sugar Company.



The cane was Yellow Caledonia, second and third ratoons. Two crops have now been harvested from these plots.

The following table gives the fertilizer applications in pounds per acre.

POUNDS OF FERTILIZER PER ACRE

Plots	1st Season		2nd Season		Total Pounds		
	1st Fert.	2nd Fert.	3rd Fert.	4th Fert.	Nitrogen	P_2O_5	K_2O
X	257 lbs. C I*......	257 lbs. C I*......	290 lbs. N. S.**	290 lbs. N. S.	180	0	0
A A A	257 lbs. C I*...... 364 lbs. Acid Phos. 103 lbs. Sul. Pot...	257 lbs. C I*...... 364 lbs. Acid Phos. 103 lbs. Sul. Pot...	290 lbs. N. S.	290 lbs. N. S.	180	120	100
B B	257 lbs. C I....... 364 lbs. Acid Phos.	257 lbs. C I....... 364 lbs. Acid Phos.	290 lbs. N. S.	290 lbs. N. S.	180	120	0
C C	257 lbs. C I....... 103 lbs. Sul. Pot...	257 lbs. C I....... 103 lbs. Sul. Pot...	290 lbs. N. S.	290 lbs. N. S.	180	0	100
D D	364 lbs. Acid Phos. 103 lbs. Sul. Pot...	364 lbs. Acid Phos. 103 lbs. Sul. Pot...	290 lbs. N. S.***	0	45 †	120	100

* C I = 17½% Nitrogen.
** N. S. = Nitrate of Soda, 15.5% N.
*** Applied to these plots by mistake.
† To 1919 crop only.

The sugar yields per acre for each treatment for the two crops were as follows:

Plots	Treatment	Tons of Sugar per Acre		
		1919 Crop	1921 Crop	Average
A	Nitrogen, Phos. Acid and Potash......	6.64	8.52	7.53
C	Nitrogen and Potash.................	6.88	7.94	7.41
X	Nitrogen only	5.95	6.64	6.29
B	Nitrogen and Phos. Acid.............	5.81	5.90	5.85
D	Phos. Acid and Potash, no Nitrogen..	6.09 *	4.84	5.46

The results obtained from the two crops harvested show the present need of these soils to be nitrogen and potash. Omitting phosphoric acid had very little effect on the yield (comparing A and C plots). On the other hand, omitting potash (B plots) lowered the yield by over a ton and a half of sugar per acre. The loss caused by leaving out nitrogen amounted to over two tons per acre.

An analysis of these soils showed a total acid soluble K_2O content of 0.184%, and .0048% citrate soluble P_2O_5. This is a very low potash content and such soils are expected to respond to potash applications; as was the case here. The

*** These plots received 45 lbs. of nitrogen per acre by mistake. This accounts for the higher yield obtained in 1919.**

PLANT FOOD REQUIREMENT

Onomea Sugar Co. Exp. 9, 1921 Crop

3rd. Ratoons.

73 X 54.71	49 B 46.26	25 X Discarded	1 A 60.54
74 C 56.97	50 X 48.83	26 B 38.40	2 X 52.66
75 X 53.75	51 C 59.35	27 X 38.49	3 B 41.41
76 D 43.88	52 X 70.90	28 C 55.02	4 X 46.00
77 X 51.26	53 D 38.27	29 X 44.59	5 C 56.06
78 A 62.74	54 X 43.18	30 D 31.97	6 X 38.74
79 X 47.56	55 A 61.94	31 X 44.71	7 D 32.69
80 B 46.27	56 X 44.82	32 A 50.39	8 X 48.88
81 X 48.90	57 B 39.54	33 X 48.43	9 A 50.53
82 C 56.34	58 X 46.37	34 B 46.30	10 X 59.90
83 X 47.90	59 C 58.86	35 X 40.08	11 B 48.80
84 D 30.87	60 X 43.89	36 C 55.40	12 X 44.07
85 X 29.61	61 D 37.06	37 X 40.10	13 C 62.81
86 A 56.95	62 X Discarded	38 D 32.43	14 X 51.07
87 X 45.94	63 A 58.24	39 X 41.99	15 D 37.11
88 B Discarded	64 X 50.05	40 A 50.28	16 X 53.11
89 X Discarded	65 B 42.41	41 X 42.11	17 A 61.55
90 C Discarded	66 X 47.40	42 B 46.38	18 X 50.06
91 X Discarded	67 C 54.16	43 X 47.64	19 B 47.62
92 D 34.02	68 X 45.66	44 C 61.12	20 X 53.65
93 X 45.29	69 D 25.63	45 X 51.91	21 C 61.69
94 A 58.05	70 X 43.05	46 D 45.95	22 X 64.44
95 X 47.84	71 A 54.12	47 X 51.06	23 D 39.53
96 B 42.44	72 X 45.65	48 A Discarded	24 X 51.49

Field Road

Summary of Results

Plot	No. of Plot	Treatment			Yields Per Acre			Gain or Loss Over Adjoining X Plots	
		Nitrogen	K_2O	P_2O_5	Cane	Q.R.	Sugar	Cane	Sugar
X	48	180	–	–	47.02	7.08	6.64		
A	12	180	100	120	62.53	7.34	8.52	+15.51	+1.88
B	12	180	–	120	44.08	7.47	5.90	– 2.94	– 0.74
C	12	180	100	–	57.98	7.30	7.94	+10.96	+1.30
D	12	–	100	120	35.78	7.39	4.84	–11.24	– 1.80

phosphoric acid is high and the field test gave no response from the use of this compound.

DETAILS OF EXPERIMENT.

Object:

To determine the plant food requirements of sugar cane on the soils of the Hilo district. The comparison is made between:

1. Nitrogen alone.
2. Nitrogen and phosphoric acid and potash.
3. Nitrogen and phosphoric acid.
4. Nitrogen and potash.
5. Phosphoric acid and potash.

NOTE:—This is a repetition of Onomea Experiment 9 (1919 Crop).

Location:

Onomea Sugar Company, Field 3, on field path leading to the Japanese Cemetery.

Crop:

Yellow Caledonia, third ratoons.

Layout:

Number of plots = 96.

Size of plots = 1/15 acre, consisting of 6 lines, each line 5.66′ wide and 85.4′ long. A two-foot space separates each plot. The front line of plots 1–24 is on the field path, although plot stakes are put in 4′ to prevent them from being knocked out.

Plan:

FERTILIZATION IN POUNDS PER ACRE OF NITROGEN, PHOSPHORIC ACID, AND POTASH.

Plot	No. of Plot	Sept. 15, 1919			Nov. 15, 1919			Jan. 15 1920	April 15 1920	Total		
		N. as C—1	P_2O_5	K_2O	N. as C—1	P_2O_5	K_2O	N. as N. S.	N. as N. S.	N.	P_2O_5	K_2O
X	48	45	0	0	45	0	0	45	45	180	0	0
A	12	45	60	50	45	60	50	45	45	180	120	100
B	12	45	60	0	45	60	0	45	45	180	120	0
C	12	45	0	50	45	0	50	45	45	180	0	100
D	12	0	60	50	0	60	50	0	0	0	120	100

C—1 = 17½% N. (8¾ sul. amn., 8¾ nitrate of soda).
P_2O_5 as acid phosphate (16.5% P_2O_5).
K_2O as sulphate of ammonia (48.68% K_2O).

Experiment planned in 1917 by L. D. Larsen and W. P. Alexander.
Experiment laid out in 1917 by W. P. Alexander.

J. A. V.

Liming at the First Mill.

Editor Hawaiian Planters' Record: — A recent number of the Louisiana Planter contained an article (reprinted in The Record for June, 1921), by Maurice Bird on "An Innovation in the Manner of Liming Cane Juice." The method of liming there described is identical (except in a few minor details) with the process worked out by a Mr. Ruggles of Cuba, and incorporated in the design for a sugar factory by Mr. O. B. Stillman, of New York and Cuba, in 1899 or 1900. This factory was constructed for the American Sugar Co. of Molokai, but was purchased by the McBryde Sugar Co. and erected on their plantation on Kauai in 1901. The system of applying all the lime required for clarification to the bagasse immediately on its issuance from the first mill was practiced in McBryde mill during the six years from 1901 to 1907 that I was connected with that company. I made a full report on the process, which was presented by the Machinery Committee to the Planters' Association meeting in 1903, and is probably available in one of the numbers of The Hawaiian Planters' Monthly for 1904. That report was rather enthusiastic, and although I did not overstate the advantages of the process, I overlooked (or had not then experienced) its disadvantages. For instance, the bagasse takes up, not only the lime required for clarifying, but a very large quantity which it retains through all the subsequent macerations and crushings in the manner that vegetable fibers "fix" mordants and dyes. The process thus requires (I quote from memory) over *three times* the quantity of lime that is required by the ordinary defecation process.

Mr. Ruggles' original intention was to produce a friable, non-fusible ash and so eliminate the destructive effect of the very fusible potash silicate ash on the arches, walls, and ash pits of the furnaces, in which forced draft was employed and the temperature intense. His process was not entirely successful in this direction (at any rate at McBryde), unless a very large excess of lime was added at the mills. This latter contingency he provided for by installing a sulphuring apparatus as part of his system.

Mr. Weinrich, of Cuba and New York, secured a patent in 1904 for a similar process, about which he and Mr. O. B. Stillman had a somewhat heated controversy in the pages of the International Sugar Journal of that year. Mr. Bird, therefore, has been anticipated by quite a few years, so far as the liming is concerned, but his addition of "a pint of formaldehyde twice a day" is distinctly novel. A quart of formalin in 200,000 gallons of juice would be a painfully small voice in a very vast wilderness. JAS. W. DONALD.

Kekaha, Kauai, Hawaii, July 6, 1921.

The Value of Potash in Hamakua.

HAMAKUA MILL COMPANY. OBSERVATION TEST B.

This test was intended, primarily, for purposes of observation, in order to obtain some idea of the potash requirements of Hamakua soils as quickly as possible.

The test was laid out in a plant field of Yellow Caledonia. This field was planted in May, 1919, and not cut back. The experiment was not started until February, 1920. It is possible that had the potash been applied earlier the response would have been greater. At the time of laying out the experiment, all the field had received five hundred pounds of high grade fertilizer per acre. This fertilizer contained eleven per cent nitrogen, six per cent phosphoric acid, and seven per cent potash. During the second season nitrate of soda was used uniformly on all the plots.

The amounts of potash used and the yields obtained are given in the following table:

TREATMENT	Lbs. Potash per Acre	Tons per Acre	
		Cane	Sugar
500 lbs. H. G. *....................	35	22.8	2.98
" 285 lbs. mol. ash **.....	130	24.9	3.33
" 570 lbs. "	230	23.8	3.28

* H. G. = 11% N., 6% P_2O_5, 7% K_2O.
** Molasses Ash = 33.5% K_2O.

Increasing the potash in this case from 35 to 130 pounds per acre increased the yield of sugar 0.35 ton per acre, or about 12%. Larger amounts of potash produced no further gains.

The soil in this case had a potash content of 0.44% total acid soluble K_2O. This has generally been regarded as fairly high.

Fields in other parts of the islands, notably at Waipio, with a lower potash content have shown no response to potash applications. This shows the difficulty of attempting to gage fertilizer requirements from soil analysis and shows the importance of field tests on the different soil types.

DETAILS OF EXPERIMENT.

Object:

To observe:

(1) The value of additional applications of potash.

(2) The amount of potash to apply.

Location:

Hamakua Mill Company, Field 18 J.

Crop:

Yellow Caledonia, plant cane (planted May, 1919).

Layout:

Number of plots = 19.

Size of plots = 1/10 acre, consisting of 6 lines, each line 4.83 feet wide and 150 feet long.

Plan:

Plots	No. of Plots	Plot Numbers	Lbs. K_2O per Acre	Lbs. Mol. Ash per Acre (33.68% K_2O)
X	7	1, 4, 7, 10, 13, 16 19................	0	0
A	6	2, 5, 8, 11, 14, 17...................	95	285
B	6	3, 6, 9, 12, 15, 18..................	195	570

Previous Fertilization:

Five hundred pounds per acre of High Grade (11% N., 6% P_2O_5, 7% K_2O), giving about 35 pounds of potash per acre.

Subsequent Fertilization:

Nitrate of soda only, uniformly to all plots; applied by the plantation.

J. A. V.

Where Greatest Attention Is Required in Power-Plants.*

Boilers differ in their operation from other power-plant equipment in that it is possible to operate all types of good design up to practically the same efficiency, irrespective of their size. With other power-plant equipment, with the possible exception of oil engines, the efficiency is fixed to a large degree by the size of the apparatus. In standard electric generators and motors the efficiency for small sizes ranges down to around sixty to seventy per cent, whereas in the larger sizes efficiency as high as ninety-eight per cent has been obtained. With large steam turbines operating on high-pressure high-temperature steam expanding down to low vacuum, their best water rate is down to between ten and eleven pounds per kilowatt-hour; with small units the water rate may be nearly double this. With reciprocating engines similar wide ranges in steam consumption are found, also considerable difference of efficiency in engines of the same size but of different types.

With boilers it is possible to obtain around eighty per cent efficiency with almost any type burning a fairly good grade of coal. There is, however, no other part of the station equipment in which there are so many factors under human control that influence the efficiency as with the boiler. When an electric generator has been properly designed and installed, its efficiency is practically fixed irrespective of what the attendants may do. If the machine is neglected, its service may be impaired, but its efficiency will remain the same under given load conditions. This is true of the turbine and steam engine, although not to

* From "Power."

the degree that it is for the electric generators. However, when the former are properly installed and put in condition to operate at their best water rates for given loads, they will continue to operate at these efficiencies for considerable periods, when expanding through a given range of pressure and temperature. Although conditions of the turbine blading, and valves and valve gears of reciprocating engines will influence efficiency, this in general becomes a serious factor only after considerable periods of service. But the efficiency of boilers is influenced by a number of factors immediately under the control of the operators—the amount of air, methods of firing, condition of boiler surfaces, both inside and out, temperature of feed water, etc.—all of which, if not given the continuous attention of the operator, may cause serious loss of efficiency. In addition the arrangement of baffling, proper heat insulation, not only of the exposed surface of the boiler but also of the settings, and the prevention of air leaks into the furnace may have a marked influence on efficiency. As a result, instead of boilers operating at an efficiency of around eighty, many are found operating at fifty or less.

Although much has been done during recent years in the development of apparatus to eliminate the human element in boiler operation, this part of the plant remains the one requiring the greatest attention. Furthermore, the evidence indicates that it is going to continue to require the greatest interest, and strange as it may seem, it is only at this late date that there is a realization that graduation of power-plant operators should be from the engine room to the boiler room, rather than from the boiler room to the engine room.

[W. E. S.]

Amounts of Nitrogen Applications.

WAILUKU EXPERIMENT NO. 1 — 1917, 1919, AND 1921 CROPS.

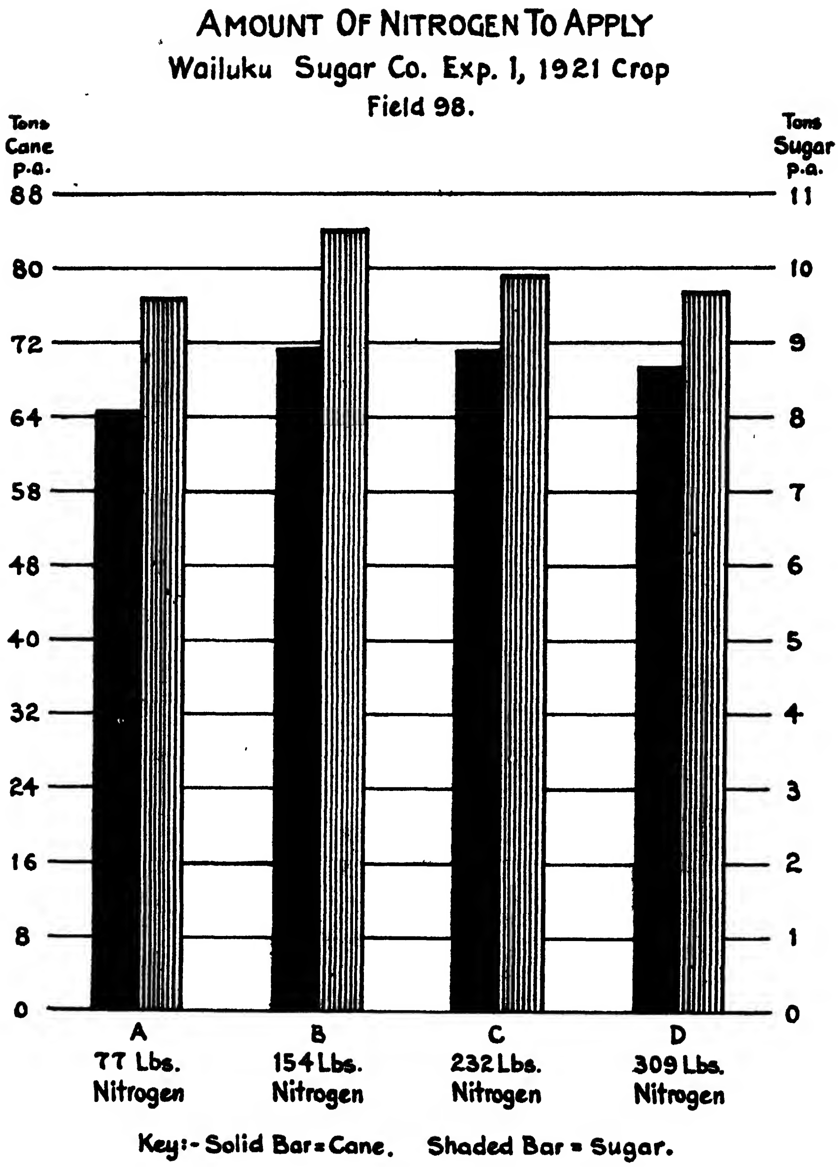
This was an experiment to determine the economic limit in nitrogen applications. The experimental cane was Lahaina. The first crop (1917) was plant, the other two, long ratoons. The test area was well irrigated and did not suffer from lack of water.

The amounts of nitrogen used varied from 77 to 309 pounds per acre, obtained from complete fertilizer and nitrate of soda. The amounts of fertilizer used and the yields obtained from each crop are given in the following table:

1917 CROP — PLANT.

No. of Plots	Treatment	Lbs. Nitrogen per Acre	Total per Acre	
			Cane	Sugar
36	900 lbs. C. F.* 200 lbs. N. S.........	112	81.6	12.07
12	1200 lbs. " "	139	83.8	12.24
12	1500 lbs. " "	166	84.6	12.30
12	1800 lbs. " "	193	89.5	13.01

* C. F. = 9% N., 7% P_2O_5, 3½% K_2O.



1919 CROP — FIRST RATOON.

No. of Plots	Treatment				Lbs. Nitrogen per Acre	Total per Acre	
	Aug., '17 B 5*	Nov., '17 B 5*	Feb., '18 N. S.	May, '18 N. S.		Cane	Sugar
18	175 lbs.	175 lbs.	125 lbs.	125 lbs.	77	66.6	10.39
18	350 lbs.	350 lbs.	250 lbs.	250 lbs.	154	75.0	11.27
18	525 lbs.	525 lbs.	375 lbs.	375 lbs.	232	75.0	10.92
18	700 lbs.	700 lbs.	500 lbs.	500 lbs.	309	74.1	10.88

*B 5 = 11% N., 8% P_2O_5.

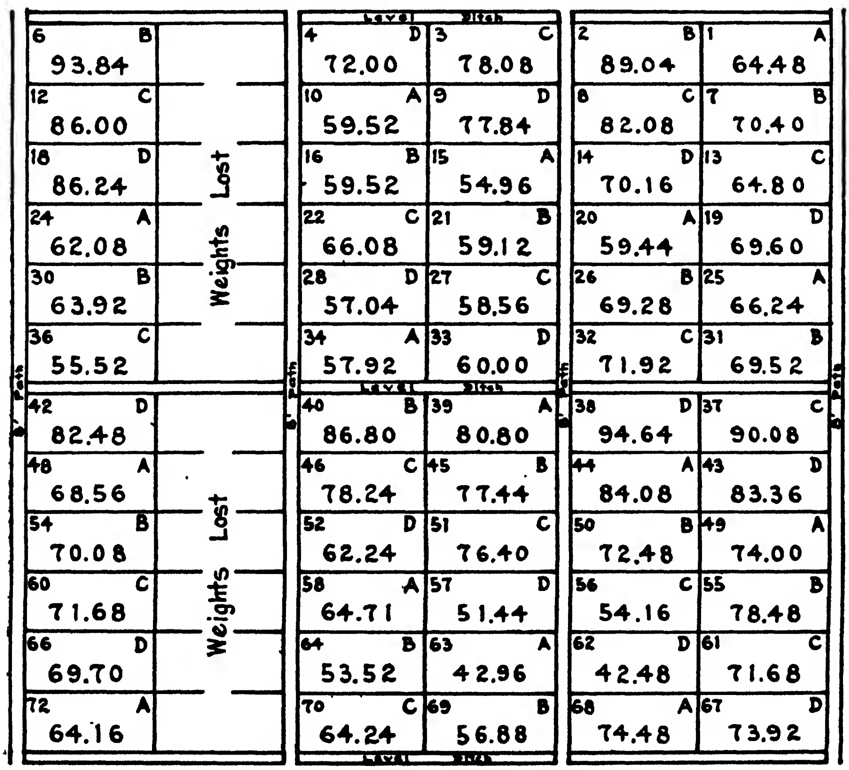
1921 CROP — SECOND RATOON.

No. of Plots	Treatment				Lbs. Nitrogen per Acre	Tons per Acre	
	Aug., '19 B 6 *	Nov., '19 B 6 *	Feb. '20 N. S.	Apr., '20 N. S.		Cane	Sugar
18	175 lbs.	175 lbs.	125 lbs.	125 lbs.	77	64.7	9.58
18	350 lbs.	350 lbs.	250 lbs.	250 lbs.	154	71.3	10.51
18	525 lbs.	525 lbs.	375 lbs.	375 lbs.	232	71.3	9.89
18	700 lbs.	700 lbs.	500 lbs.	500 lbs.	309	69.3	9.67

* B 6 = 11% N., 6% P_2O_5.

AMOUNT OF NITROGEN TO APPLY

Wailuku Sugar Co. Exp. 1, 1921 crop
Field 98.



Summary of Results

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	18	77 Pounds Nitrogen	64.75	6.76	9.58
B	18	154 Pounds Nitrogen	71.35	6.79	10.51
C	18	232 Pounds Nitrogen	71.30	7.21	9.89
D	18	309 Pounds Nitrogen	69.27	7.14	9.67

With the plant crop, harvested in 1917, profitable gains were obtained up to 193 pounds, say 200 pounds, per acre of nitrogen. With the two ratoon crops, the profitable limit dropped to 154 pounds of nitrogen per acre. Further additions of nitrogen produced no increase in cane and lowered the quality of juices, thereby decreasing the output of sugar.

DETAILS OF EXPERIMENT.

FERTILIZATION: AMOUNT TO APPLY, 1921 CROP.

Object:

To determine the most profitable amount of fertilizer to apply on Lahaina ratoons at Wailuku.

Location:

Wailuku Sugar Company, Field 98, Plots 1–72.

Crop:

Lahaina, second ratoons.

Layout:

Number of plots = 72.

Size of plots = 1/16 acre, consisting of 8 furrows, 4½ feet wide and 75½ feet long. Measurements taken from middle of water course to middle of water course. The plots are separated from each other by a blank furrow.

Plan:

FERTILIZATION, POUNDS PER ACRE.*

Plots	No. of Plots	Aug. 1, 1919	Nov. 1, 1919	Feb. 1, 1920	May 1, 1920	Total Lbs. Nitrogen
A	18	175 lbs. B-6	175 lbs. B-6	125 lbs. Nit.	125 lbs. Nit.	77
B	18	350 lbs. B-6	350 lbs. B-6	250 lbs. Nit.	250 lbs. Nit.	154
C	18	525 lbs. B-6	525 lbs. B-6	375 lbs. Nit.	375 lbs. Nit.	232
D	18	700 lbs. B-6	700 lbs. B-6	500 lbs. Nit.	500 lbs. Nit.	309

* B-6 = Regular Brewer & Co. fertilizer known as—

B-6 = 11% Nit. (4½% sul., 4½% nit., 2% organic), 6% Phos. Acid (3% bone-meal, 3% superphos.).

Nitrate of Soda = 15.5% Nitrogen.

NOTE: — With the plant crop one-half of the experiment received coral sand at the rate of 10 tons per acre.

Experiment originally planned by L. D. Larsen.

Experiment originally laid out by Messrs. Ayres and Gross of Wailuku Sugar Company.

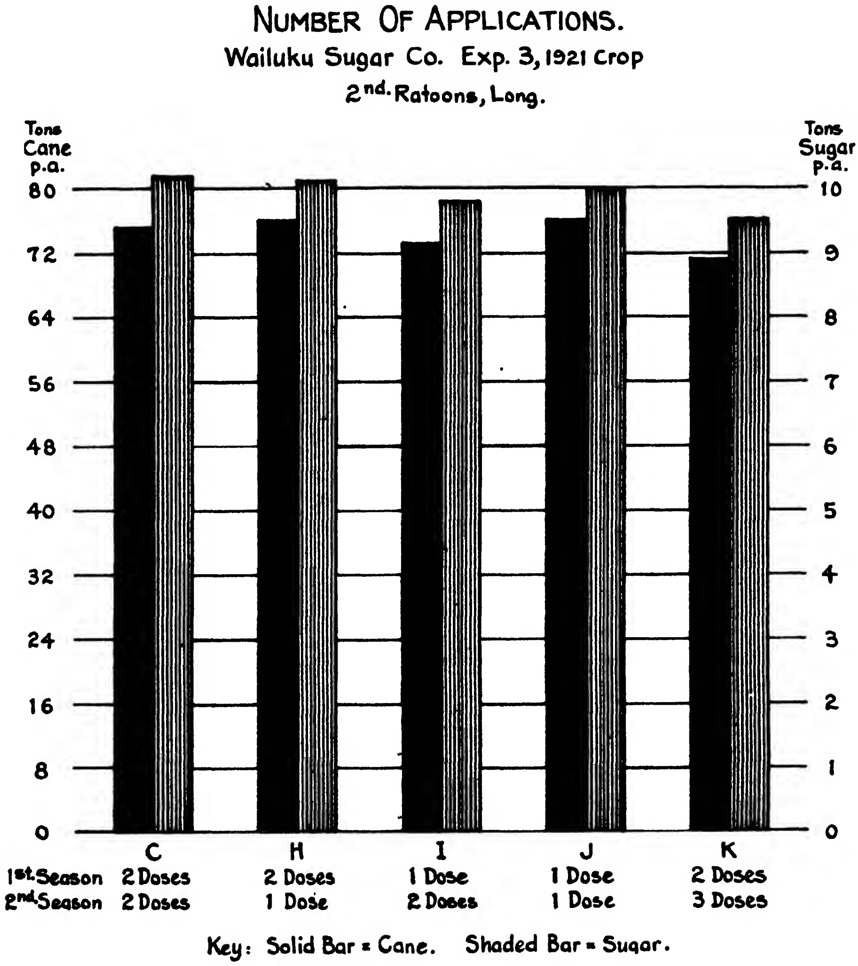
J. A. V.

The Number of Doses in Which to Apply a Given Amount of Fertilizer.

WAILUKU SUGAR COMPANY, EXPERIMENT NO. 3, 1921 CROP.

This was an experiment to determine the best number of doses in which to apply a given amount of fertilizer.

The cane was Lahaina, second ratoons, long, in an irrigated field. The field was harvested late in March and was 21 months old at the time. All plots received the same amount of fertilizer, one-half of the nitrogen being applied each



season. A total of 200 pounds of nitrogen per acre was used. During the first season B 6, a mixed fertilizer, was applied and nitrate of soda during the second season. The number of doses in which the above fertilizers were used varied from two to five.

The following table gives the amounts and time of application:

POUNDS OF FERTILIZER PER ACRE.

Plots	No. of Plots	Aug., 1919 B 6*	Nov., 1919 B 6*	Feb., 1920 Nit. Soda	Apr., 1920 Nit. Soda	June, 1920 Nit. Soda	Total Pounds	
							Nit.	P_2O_5
C	17	455	455	323	322	0	200	55
H	16	455	455	645	0	0	200	55
I	17	910	0	323	322	0	200	55
J	17	910	0	645	0	0	200	55
K	17	455	455	215	215	215	200	55

*B 6 = 11% N., 6% P_2O_5.

The results obtained from the different treatments were as follows:

Plots	No. of Applications	Tons per Acre		
		Cane	Q. R.	Sugar
J	2 Applications..............	76.1	7.61	10.00
H & I	3 "	74.7	7.50	9.96
C	4 "	75.4	7.37	10.21
K	5 "	71.3	7.50	9.51

The results from the use of two, three or four doses of fertilizer vary but little. When the fertilizer was applied in five doses the yields were distinctly lower.

DETAILS OF EXPERIMENT.

FERTILIZATION — NUMBER OF APPLICATIONS.

Object:

To compare the following methods of application:

(1) Four equal doses, two in first and two in second season.
(2) Three doses, two in first, one in second season.
(3) Three doses, one in first, two in second season.
(4) Two doses, one in first, one in second season.
(5) Five doses, two in first, three in second season.

In all cases half of the fertilizer is applied each season.

Location:

Wailuku Sugar Company, Field No. 98.

Layout:

Number of plots = 84.

Size of plots = 1/16 acre, consisting of 8 lines, each 4.5′ wide and 75.5′ long. One blank line left between each plot. This area comprises former Wailuku experiments Nos. 3 and 4.

Number Of Applications

Wailuku Sugar Co. Exp. 3, 1921 Crop

2nd Ratoons, Long.

		Level	Ditch		
78 C 83.92	77 K 78.56	76 J 89.04	75 I 71.44	74 H 94.08	73 C 92.96
84 K 80.72	83 J 76.08	82 I 96.00	81 H 58.08	80 C 83.44	79 K 82.72
90 J 80.96	89 I 68.16	88 H 66.88	87 C 54.96	86 K 90.56	85 J 81.52
96 I 67.76	95 H 59.92	94 C 61.76	93 K 58.08	92 J 77.28	91 I 84.40
102 H 75.92	101 C 58.08	100 K 53.76	99 J 61.28	98 I 73.60	97 H 91.44
108 C 83.84	107 K 76.32	106 J 74.24	105 I 61.84	104 H 83.52	103 C 81.20
		Level	Ditch		
114 K 87.92	113 J 91.12	112 I 88.88	111 H 87.04	110 C 95.76	109 K 68.88
120 J 95.12	119 I 86.80	118 H 91.52	117 C 78.48	116 K 76.80	115 J 82.64
126 I 93.04	125 H 66.48	124 C 89.52	123 K 71.36	122 J 72.88	121 I 91.92
132 H 91.36	131 C 70.88	130 K 86.88	129 J 68.72	128 I 75.20	127 H 74.16
138 C 92.24	137 K 79.28	136 J 78.52	135 I 61.04	134 H 72.48	133 C 65.10
144 K 81.28	143 J 74.40	142 I 75.28	141 H 62.32	140 C 66.56	139 K 53.52
150 J 83.84	149 I 75.44	148 H 77.92	147 C 52.32	146 K 40.48	145 J 49.92
156 I 74.72	155 H 64.64	154 C 69.84	153 K 45.60	152 J 47.36	151 I 53.68
		Level	Ditch		

8' Path

Summary of Results

Plots	No. of Plots	Treatment		Tons Per Acre		
		1st Season	2nd Season	Cane	Q.R.	Sugar
C	17	2 Doses	2 Doses	75.35	7.37	10.21
H	16	2 "	1 Dose	76.11	7.52	10.12
I	17	1 Dose	2 Doses	73.26	7.47	9.80
J	17	1 "	1 Dose	76.11	7.61	10.00
K	17	2 Doses	3 Doses	71.34	7.50	9.51

Note - ½ Nitrogen 1st season. ½ 2nd season.

Plan:

FERTILIZATION*—POUNDS OF NITROGEN PER ACRE.

Plots	No. of Plots	1st Season: Sept. 1, 1919	1st Season: Nov. 1, 1919	2nd Season: Feb. 15, 1920	2nd Season: April 15, 1920	2nd Season: June 15, 1920
C	17	50	50	50	50	0
H	16	50	50	100	0	0
I	17	100	0	50	50	0
J	17	100	0	100	0	0
K	17	50	50	33½	33⅓	33⅓

* Fertilizer: First season, B 6 = 11% N., 6% P_2O_5. Second season, Nitrate of soda = 15.5% N.

Experiment planned by J. A. Verret.
Experiment laid out by L. T. Lyman.

J. A. V.

Fertilizer—Time and Number of Applications.

WAIPIO EXPERIMENT B. 1921 CROP.

The experimental cane was H 109, first ratoons, long, and was twenty-four months old when harvested, at which time it had not been irrigated for one hundred days. The cane was harvested June 29 to July 13.

All plots received nitrate of soda at the rate of 1613 pounds per acre, equivalent to 250 pounds of nitrogen per acre. No other form of fertilizer was used.

The fertilizations received by the different plots are given in the following table:

Plots	No. of Plots	Pounds Nitrate of Soda per Acre: Aug., 1919	Nov., 1919	Feb., 1920	May, 1920	Total Nitrogen
A	12	807	0	806	0	250 lbs.
B	12	807	0	403	403	"
C	12	403	403	403	404	"
D	12	403	403	807	0	"
E	12	403	0	1210	0	"
F	12	1210	0	403	0	"

The results obtained are given as follows:

TABLE I—NUMBER OF APPLICATIONS.

Plots	Number of Applications	Tons per Acre: Cane	Q. R.	Sugar
A, E, F	2	110.6	7.70	14.36
B, D	3	111.6	7.67	14.56
C	4	110.5	7.66	14.42

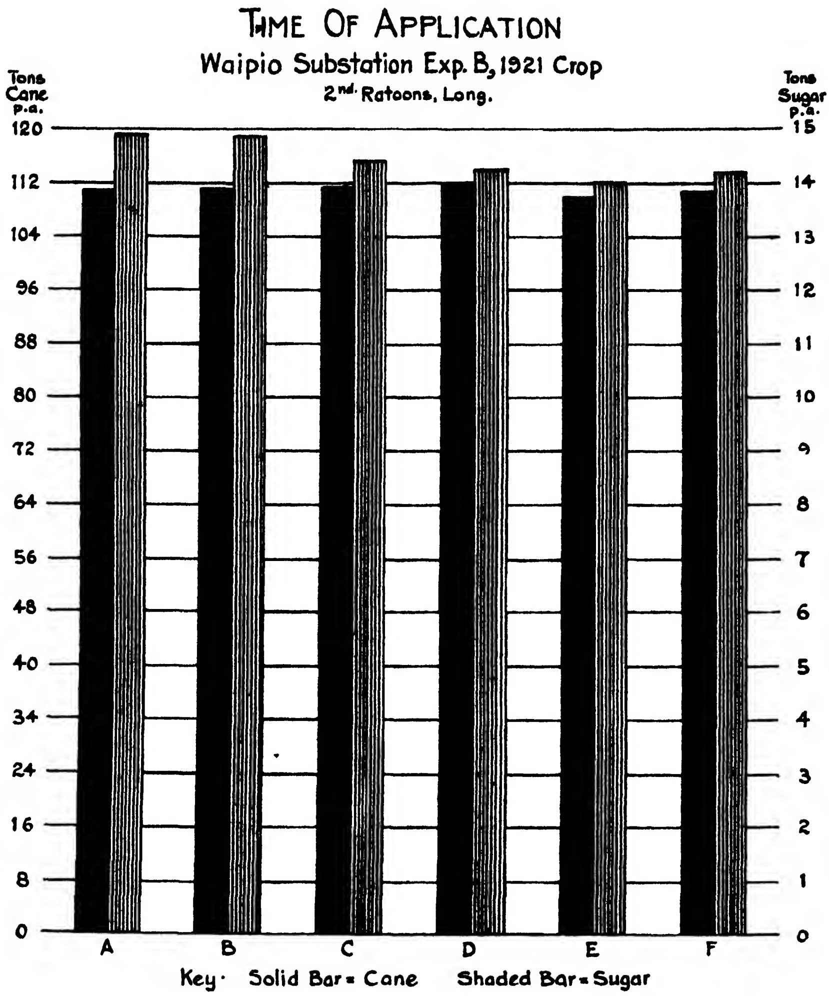


TABLE II — PROPORTION OF FERTILIZER TO APPLY EACH SEASON.

Plots	Methods of Application		Tons per Acre		
	First Season	Second Season	Cane	Q. R.	Sugar
A, B, C, D	½	½	111.2	7.61	14.61
E	¼	¾	110.0	7.85	14.01
F	¾	¼	110.6	7.80	14.17

The yields given in Table I show a most remarkable uniformity. Were all the plots to receive identical treatment closer checks could not be expected. It made no difference at all whether the fertilizer was applied in two, three, or four doses.

The results given in Table II also show close agreement for the different treatments, but there would seem to be a slight tendency in favor of dividing the fertilizer equally between the two seasons.

In both of the tables given above there is much more variation in the yields of sugar than in that of the cane. We feel that these greater variations in the

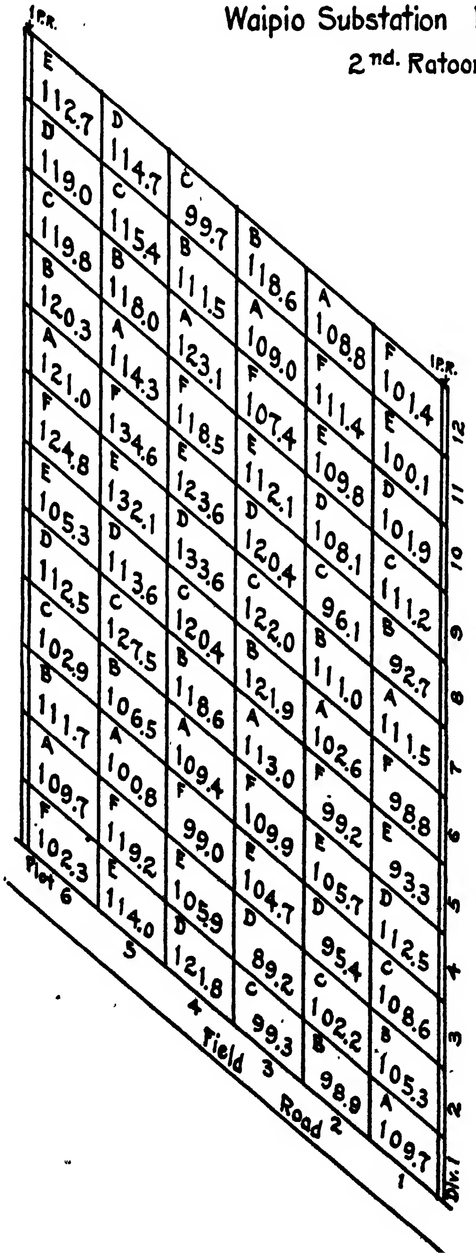
yields of sugar are due more to difficulties in sampling and in varying intervals of time between burning and sampling at the mill, than to the various fertilizer treatments.

The average composition of the juices from all the plots was 20.1 brix, 17.48 polarization, and 87 purity. The yields reported from all Waipio experiments are reduced sixteen per cent to account for ditches and water courses, so that the figures given will be directly comparable with those of other irrigated plantations.

TIME OF APPLICATION

Waipio Substation Exp. B, 1921 Crop

2nd. Ratoons, Long.



Summary of Results

Plots	No. of Plots	Treatment 1st. Season	Treatment 2nd. Season	Treatment Nitrogen	Tons Per Acre Cane	Tons Per Acre Q.R.	Tons Per Acre Sugar
A	12	+	+	250*	111.1	7.45	14.91
B	12	+	++	250*	111.3	7.47	14.89
C	12	++	++	250*	111.5	7.66	14.42
D	12	++	+	250*	111.9	7.86	14.24
E	12	+	+	250*	110.0	7.85	14.01
F	12	+	+	250*	110.6	7.80	14.17

DETAILS OF EXPERIMENT.

Object:

1. To determine the proportion of fertilizer to apply each season.
2. To determine the most profitable number of doses.

Location:

Waipio Substation — Section 3, Experiment B.

Crop:

H 109, first ratoons, long.

Layout:

Number of plots = 78.
Size of each plot = 1/30 acre.
Number rows per plot = 8.

Plan:

Fertilizer to be applied each season as follows (reported in pounds nitrogen per acre):

Plot	No. of Plots	First Season		Second Season		Total Lbs. Nitrogen
		Aug., '19	Oct., '19	Feb., '20	May, '20	
A	12	125	0	125	0	250
B	12	125	0	62.5	62.5	250
C	12	62.5	62.5	62.5	62.5	250
D	12	62.5	62.5	125	0	250
E	12	62.5	0	187.5	0	250
F	12	187.5	0	62.5	0	250

Nitrogen to be obtained from Nitrate of Soda 15.5% N.

Experiment planned by J. A. Verret.
Experiment laid out by R. M. Allen.
Experiment harvested by A. Paris.

J. A. V.

Improvement of Rice by Selection and Hybridization in Java.*

The methods of selection employed at Buitenzorg on the same lines as those employed at Svalof for the cereals in Northern Europe are based on the following facts, in accordance with botanical and genetical theories held by a large number of specialists:

(1) The cultivated varieties of rice (these should not be confused with botanical varieties) include a considerable number of fixed strains, similar to those known in the botanical world under the name of "sub-species" or "Jordan species."

(2) Each of these strains differs from the surrounding types of the same

* Wiellard, P., in Bulletin agricole de l'Institut scientifique de Saigon (Year 11, No. 1, pp. 11-15, Saigon, Jan. 1920), as abstracted in International Review of the Science and Practice of Agriculture—Year XI, No. 5, May, 1920.

variety in characters of negligible importance morphologically, but which mean a great deal from the cultural standpoint (e. g.: yield, early maturity, resistance to disease, etc.). These distinctive characters are admittedly entirely transmissible to progeny.

(3) Compared with the habit of several other cereals, self-pollination is the usual habit with rice, and cross-pollination is very rare. This certainly facilitates to a large extent the process of selection, as it permits close spacing, and of several pure lines coming from the same or different varieties, without running the risk of undesirable crosses.

It is easy to see, therefore, that if a cultural variety is selected which shows a combination of good characters (weight of yield, quality of grain, resistance to disease), or which possesses one of these points to a marked extent, it will be sufficient to multiply a pure line to obtain several generations later, a new cultural variety following the natural course, but with the advantage of each individual possessing qualities of a select strain superior in one form or another to the original variety ("population").

The following is a brief survey of the method employed in Java at Tjikenneuth.

The "population" rice is sown in the nursery according to the usual custom, and then pricked out on to an area of about 20 acres, with much care taken to avoid putting more than one plant into each hole. Throughout the growing period, the rice field is watched, and out of the 10,000 or 200,000 plants thus pricked out, about 300 select types are chosen.

The record of the yield of each plant is made separately. In the laboratory, the less interesting ones are eliminated, and about 75 to 80 in all, are conserved. These will form the origin of the pure line selection.

The following year, each of the 75 to 80 lines thus obtained is sown and re-pricked out, always at equal distances apart, on small plots (4.7 to 7 sq. yds.). Three plots at least are reserved for each line and these are distributed in various quarters of the field, so as to avoid variations due to dissimilarity of soil. In the harvest season, the produce from all the plots is collected at the same time. In this way 75 to 80 crops are obtained, and these are investigated in the laboratory according to the characters it is desirable to retain.

The third year, work is not continued with the 10 to 15 best lines in the second selection, but this time the plots reserved for each line and these are multiplied as far as possible. The crops thereby obtained serve as a base for the definite choice of the type, or types, which will advantageously take the place of the original "population."

At Java, up to the present time, a dozen varieties have undergone this method of selection and have furnished twenty pure lines. These lines multiplied over large areas, for the last two or three years in control plots, have shown homogeneity and fixed characters as expected. With regard to the yield, there was an average increase of 20%.

It is noticeable, as predicted, that the results obtained showed a distinct improvement to the original and less homogenous population.

The Tjikenneuh Station is assisted in plant breeding work by the co-operation of the "Jardins de semences" directed by M. Van Der Stok, and the work

extends over the center and east of Java and to demonstration fields at the local agricultural schools. It is reasonable, therefore, to hope that the results, already distinctly advantageous, will be accentuated and confirmed in the near future.

The author gives a brief survey of the hybridization experiments made at Tjikenneuth.

Artificial pollination of rice is a somewhat difficult operation, which was for a long time considered impossible.

M. Van Der Stok, who was the first to succeed, has, however, never obtained more than a very minor degree of success. The local varieties, crossed seven years before and with progeny followed with great care up to the present time, are "Skriviman Koti" and "Carolina." The first is a plant of very considerable vigor, leaves dark green, form erect. The yield is high, but unfortunately the grain is of an inferior quality. The second variety, on the contrary, shows lack of vigor, the leaves are large, light green and drooping, but it makes up for this by producing grain, although in poor quantities, of the biggest and best quality obtainable in Java and perhaps even in the whole world. The flowering period is three weeks earlier than that of Skriviman Koti.

Hybrids are selected in each generation. F, under the author's observation, gave more than 200 hybrids cultivated on plots of an average area of 7 sq. yd., and which showed a combination of characters of the two parents. In several cases "transgression" was noted.

Certain hybrids flowered eight days earlier than Carolina (the variety which matures the quicker of the two parents). Others gave larger grain than Carolina. These facts are sufficiently encouraging to raise hopes, and the confirmation of the results obtained at Tjikenneuth will open up an efficient means of action to rice breeders for the improvement of local varieties, by crossing with superior imported varieties.

The Dwarf Coconut in the Federated Malay States.*

The increasing rise in the price of copra having given renewed activity to coconut planting in this country, it is important that some facts of this interesting variety of coconut should be put on record.

Description: The dwarf coconut, known in this country as "nyiur gading," is remarkable for its early fruiting, palms only 10 feet high bearing abundant fruits touching the ground. The young palm grown under good conditions starts to flower in its third year and produces ripe fruit in about nine months from the appearance of the flower spike. The initial flower spikes contain only male flowers, but other spikes occurring in rapid succession, are larger and bear an increasing number of female flowers, one spike from a six-year-old tree bearing 200 young female flowers, whilst trusses of fruit from similar trees have been found with as many as 55 ripe nuts.

*** Handover, W. P., in The Agricultural Bulletin of the Federated Malay States, Vol. VIII, No. 5, p. 295–297. Kuala Lumpur, Sept.-Oct. 1919.**

The dwarf coconut is generally of a bright yellow color. There is besides a distinct brick-red variety, also a green variety and a number of intermediate colors which might be ranged as ivory yellow "gading," golden yellow, orange brick-red, green bronze, and deep green. The flower spikes, leaf bases, and leaf ribs correspond in color with the fruit, giving the compact trees a very handsome appearance. Again there are semi-tall trees of these different colors, which are later coming into bearing, having slightly larger nuts, and are less prolific than the true dwarf.

The dwarf yellow strain appears as the most prolific, whilst the other varieties vary proportionately in their productiveness and also in the shape and size of the nut, and are evidently the outcome of cross-fertilization from original types or "mutants" (1).

The different varieties are distinguished amongst the Malays and Javanese under particular names, such as "nyur," "(klapa)gading," "k. merah, (or sajah)," "k. kapak," "k. pisang," "k. puyok," "k. hahi," "sepang," and "k. nipah."

A full-grown leaf of the "nyiur gading" measures only 12 feet from base to tip, whilst the ripe nut measures 22½ inches by 24, and the stem 24 inches in girth; the nut has an average amount of fiber, a thin shell, and proportionately with the big nut, a good thickness of white kernel.

This "meat" is said by the Malays to be richer in oil and sweeter in taste than that of the big coconut, and it is therefore very popular with them for domestic purposes.

History: In spite of diligent inquiry, it has not been possible for the author to find out the definite origin of this dwarf nut, but it seems first to have occurred as a "sport" or "mutant," probably in Java. Trees, thirty years old or so, occur in different parts of the peninsula and many of these still bear abundantly.

In 1912, 500 acres were planted with these dwarf nuts at Sungei Nipah Estate on the coast between Port Dickson and Sepang Point, and this is probably the only estate of dwarf coconuts in the world.

Growth: Like all coconuts, this dwarf form appears to be exceedingly hardy, growing well either in white clay, red loam, or deep peat; in fact it seems to thrive in any situation where water is abundant, yet not stagnant, though it is evident that well-drained alluvin suits it best.

In such a soil, six-year-old palms have been counted with 234 nuts (excluding ovules), and the trees average 80 nuts a year.

Crop: In the first year of production at Sungei Nipah the crop over 225 acres was 102,000 nuts, whilst the second year it was 574,000 nuts, and the third year it will probably be nearly a million; from which the author considers an average yield for dwarf nuts may be estimated as follows:

At the end of 4th year (1st yielding year).......	10 nuts per tree	
At the end of 5th year (2d yielding year).......	30 nuts per tree	
At the end of 6th year (3d yielding year).......	60 nuts per tree	
At the end of 7th year (4th yielding year).......	80 nuts per tree	
At the end of 8th year (5th yielding year).......	100 nuts per tree	
At the end of 9th year (6th yielding year).......	120 nuts per tree	(In full bearing)

These estimates, in face of yields from individual trees, will appear con-

servative, but there are many points which have to be considered when dealing with average yields, and no doubt under ideal conditions a much higher average could be obtained.

In making copra, it has been found that the nut from a young tree is smaller than that forming later, and its kernel likewise thinner, whilst of course, on heavy yileding trees the nuts are a little below the average in size, but 500 nuts to a pikul (1) of copra is a general average, which would be decreased somewhat later as more even nuts with thicker "meat" are obtained. With the leaf length only 12 feet, it was found convenient to plant the palms 24 ft. x 20 ft., which gave 90 to the acre, a number nearly double to that required when planting big palms.

It is evident, therefore, that with this planting we should get, say, in the fifth year of planting 90×30 nuts $= 2700$ nuts per acre $= 27 \div 5 = 5\ 2/5$ pikuls copra per acre. Likewise, in the ninth year $90 \times 120 = 10{,}800$ nuts per acre $= 108 \div 5 = 21\ 3/5$ pikuls copra per acre. Comparing this with the big coconut, which does not produce till after its fifth year, it might be estimated as giving in its ninth year 45 trees at 40 nuts $= 1800$ nuts per acre $= 1800 \div 220 = 8$ pikuls of copra per acre. With the dwarf trees there is the great advantage of easy and rapid picking and inspection for beetles and other pests, though of course in manufacture almost 2½ times the number of nuts per pikul of copra handled, but this is not of so great a consequence when working with newly devised methods and machinery, dealing with large quantities.

The profit per acre from five-year-old dwarf coconuts today can even stand comparison with that of rubber, and the man who is planting today has to consider markets five years ahead, and might do worse than place confidence in the dwarf coconuts.

SUGAR PRICES FOR THE MONTH

Ended August 15, 1921.

		96° Centrifugals Per Lb.	96° Centrifugals Per Ton.	Beets Per. Lb.	Beets Per Ton.
	(July 16, 1921)	4.50c	$ 90.00	No quotation.	
[1]	" 18	4.64875	92.975		
[2]	" 19	4.555	91.10		
[3]	" 20	4.61	92.20		
[4]	" 25	4.7425	94.85		
	" 26	4.61	92.20		
[5]	Aug. 1	4.86	97.20		
[6]	" 15	4.8125	96.25		

[1] This price consists of a sale of Cubas 4.61 and a sale of San Domingo at 4.6875. San Domingo sale is export.

[2] This price consists of sale of Cubas 4.61 and Porto Ricos 4.50.

[3] Cubas.

[4] This quotation covers sale of Cubas 4.61 and sale of full duties 4.875. Latter sale export.

[5] Both Porto Ricos and Cubas sold same price. Fair volume.

[6] One sale San Domingo 4.875 export. One distressed lot Porto Rico 4.75.

THE HAWAIIAN PLANTERS' RECORD

Volume XXV. OCTOBER, 1921 Number 4

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

The Moreton Bay and Port Jackson Figs for Hawaiian Forests.

There is every reason to believe that these two remarkable trees from Australia may be relied upon to serve as major components of the new forests which we must build on our denuded watersheds. They are trees of fine shape, attain large dimensions and show ability to grow under a very wide range of conditions. There are two fine large trees of the Moreton Bay fig in Honolulu and a vigorous young tree in Honomu. There is a large specimen of the Port Jackson fig on the old Tantalus Road and five young fruiting trees in the grounds of the U. S. Experiment Station. Both of these trees have been planted extensively in California and have proven hardy as far north as San Francisco, where they survive light frosts. We may therefore expect them to do well in Hawaii at all elevations from sea level up to 6000 feet. The figs produced by these trees are very attractive to fruit-eating birds, which disseminate the seeds over all areas which they chance to visit.

If we plant groves of these trees at intervals on our watersheds we can depend upon the mynah birds to spread them for us as soon as they begin to produce fruit. During the coming winter we shall have upwards of 250,000 seedling trees of these two figs of suitable size for planting out. If we can get these well distributed over the Islands we shall have laid the foundation for the gradual rehabilitation of our forests through natural agencies. We would suggest that each plantation set out several thousand of these trees on lands in or adjacent to their forest areas. These particular figs make excellent shade trees for streets and parks and may be planted to advantage along roads and about camps.

No Short Course This Year.

The delay in the harvesting season makes it inadvisable to hold a short course for plantation men this year. This conclusion is reached after writing the plantations and learning that a sufficiently large attendance cannot be expected. The previous courses have been entirely successful and the plan of holding future courses is not being abandoned. The 1921 course is omitted, all hands being needed on the job to get off the crop.

Hilling in the Hilo District. An experiment to determine the value of hilling has been harvested at the Hilo Sugar Company. In this test all plots received regular plantation cultivation, except that hilling was omitted in half the plots.

The not hilled plots produced 0.63 ton of sugar more per acre than did the plots which were hilled. Similar results were obtained from the crop harvested two years ago.

These returns are a striking contrast to those reported from McBryde Sugar Co., where hilling showed definite gains.

Cane Varieties in Pioneer Mill Company. A variety experiment has recently been harvested at the Pioneer Mill Company, in which H 33, H 109, H 146, D 1135, Lahaina, and Striped Mexican were compared on the upper lands of the plantation. The cane was two years old when harvested. Having been planted in July, 1919, it experienced the water shortage that has prevailed.

In this case the yield of D 1135 exceeded that of H 109. Lahaina and Striped Mexican were somewhat lower than H 109, and H 33 was still lower. H 146 was a failure under the conditions of the test.

Nitrates. In comparing the loss through leaching of nitrate of soda and nitrate of ammonia, little difference is found in the behavior of these two salts in cylinders holding four-foot columns of soil.

The fertilizing salts were applied at the maximum rate which is used upon the irrigated plantations, that is, 1000 pounds of sodium nitrate per acre, carrying about 155 pounds of nitrogen. First there was tried a two and a half inch irrigation upon the cylinders. With such an application about one-third of the irrigation water escaped as drainage. In two such irrigations less than 5% of the added nitrogen was carried out of the soil. With an irrigation of 5½ inches the loss was slightly higher, but with most of the soils it did not exceed 10%.

Work with these cylinders is being continued, but the results so far obtained show the high absorptive power of the Hawaiian soils. This also explains the reason why such excellent results are obtained with sodium nitrate in the rainy districts. There will be a considerable variation in the amount of nitrates retained by different soils, but it is believed that the soils used are sufficiently typical so that no fear is felt that the greater part of an application of nitrate of soda will be washed out by a heavy rain soon after its application.

Biological Control of Destructive Insects.

The following letter in "Science," August 5, 1921, is of interest:

To the Editor of Science: Control of destructive insects by the introduction of their natural enemies has become an important technique during the last generation. But if competent observers are to be trusted, the southern Arabs employed the same method more than 150 years ago, in the culture of the date-palm.

In his "Relation d'un Voyage dans l'Yemen" (Paris, 1880, p. 155), P.-E. Botta says:

> I was able to verify the singular fact previously observed by Forskål, that the date-palms in Yemen are attacked by a species of ant which would cause them to perish, if each year the growers did not bring from the mountains and fasten in the tops of the palms branches of a tree that I did not recognize, which contain the nests of another species of ant which destroys that of the date-palm.

P. Forskål was the naturalist of C. Niebuhr's expedition; his work was published posthumously in 1775. I have not seen his account to which Botta refers.

It would be interesting to know whether the history of economic entomology furnishes any earlier record of the "biological method" of pest control.—*Paul Popenoe, Therman, Calif., April* 24, 1921.

[F. M.]

Improvement of Sugar Cane Through Bud Selection.

***A Report on the Work Since May* 1, 1921.**

By Wm. W. G. Moir.

Following the work on Oahu under the direction of Mr. A. D. Shamel, selection was carried on at the following places: Maui Agricultural Company, Wailuku Sugar Company, Hilo Sugar Company, Paauhau Sugar Plantation Company, and Onomea Sugar Company. A brief report on the whole work at each place follows.

Maui Agricultural Company.

Experiments were laid out at Hamakuapoko in 1920 by Mr. E. L. Caum and the writer, covering a number of points under consideration in the selection project of the Experiment Station, such as the inherent qualities of single stools, single eyes, irregular- and uniform-stalked stools, and the spacing of seed. It might be of interest to note here that the area used for these plantings was a fallowed section of a field that was badly infested with nut-grass, and that no

fertilizer was used throughout the crop. The results obtained should be all the more interesting on this account.

The first experiment, and probably the most valuable, was a detailed study and planting of some forty single-eye stools of H 109, started in 1919 by Mr. D. Sloggett, then overseer for the Hamakuapoko section. These single-eye stools were the one-year crop from well-developed eyes selected from large stalks in the field, started in pots and later set out in the field, spaced one foot apart. The extreme variations in size of stalk, number of stalks per eye, strength of growth and color (types) were immediately apparent. In number of stalks alone the variation ranged from 0 to 12, while in strength and color one easily could be tempted to divide them into separate varieties instead of considering them as all of the same variety. All forty of the single-eye progenies were studied and the data recorded. Later they were cut up for seed and each one planted as a separate progeny. Among these there stood out two strong types, one of which was represented by two large stools of 10 and 12 stalks, respectively, that were well ahead of the others.

The 1921 crop from these progenies gave even more marked results, for the yield from the single-stalk stools was below the plantation average, while that from the strong types mentioned above was more than double the plantation average. The difference in strength of stalk, uniformity of stools, inherent power of heavy production and color type, and the marked superiority of some progenies over others were so apparent that even the laborers commented upon them. For instance, in tonnage alone for the ten-months crop the yield per progeny varied from 20 to 120 tons of cane per acre, the latter figure being that for either of the two heavy strains mentioned above.

The results obtained from the other experiments at Hamakuapoko pointed toward improvement in yield through selection. In the study of the inherent qualities of irregular and uniform stools it was found that in the majority of cases like produced like, but several remarkable exceptions were noted and kept for future study.

The most surprising point in the study of these progenies was that all those selected for further study fell within two distinct types of H 109, easily distinguished from each other, yet closely related. These two types, one large-eyed, erect and orange in color, and the other large-eyed, semi-erect and white, are by far the most desirable. They are both very common types on Maui. The difference between these types is so marked that when they are cut up into seed pieces and mixed together any laborer could separate them correctly, and he would probably say that one of them was not H 109. In a few cases single-eye plantings were found giving rise to both types. These cases were recorded and the seed planted separately.

On August 18, 1921, I visited this area and was most gratified to see the excellent stand of cane. Progeny 1 (the 10-stalk stool) and progeny 2 (the 12-stalk stool) are exceptionally good and show their inherent qualities of heavy production, while progeny 50, where two types arose from a single eye, showed its inherent ability to reproduce each type according to the seed planted. The orange type was erect and stooling slowly (typical H 109), while the white type was spread out like Lahaina, with secondary and tertiary shoots as large as the

primary—a difference as marked as the difference in growth between Lahaina and D 1135.

The Lahaina cane planted last year became infected with Lahaina disease, but one stool of 12 stalks from a single-eye planting seemed to be in the best of health. This stool was retained and planted out. The new crop seems to be maintaining the superiority of the parent stool, with its possibilities of overcoming the disease.

Ratoons are being cared for along with the plant crop, and our next year's figures and observations on these two crops will probably be the most valuable data we will have, due to the isolation of types.

Wailuku Sugar Company.

A total of 101 progenies was planted in Field 98 this year. They include 89 of H 109, 8 of Opukea, 2 of Striped Mexican, and 1 each of Lahaina and Badila. Most of these were selected from a mother-field planted last year, but as this mother field was planted close and the seed from different stools mixed, a new start on progeny work had to be made. In these progenies we have many excellent stools with as many as 25 or 30 stalks per seed piece. The stand in the newly planted area is one of the finest to be seen and will require no replanting. Here again, as at Hamakuapoko, color types became very apparent, but due to exposure to the sun and to other environmental factors, type characteristics of this nature were obliterated.

Hilo Sugar Company.

This year, with the aid of Mr. Austin of the Hilo Sugar Company, a large progeny test area has been planted in Field 4. The first stools selected were taken from the general selected area of last year, and then the selection was continued in a one-year-old plant field. Nearly 1000 stools were so obtained and planted. The remaining canes in the general selected area were used for seed to plant an adjoining block to determine the value of mass selection.

Paauhau Sugar Plantation Company.

Mr. Poole, of the Paauhau Sugar Plantation Company, has been conducting selection work at Paauhau and has secured a large planting of selected D 1135 and Yellow Caledonia, and will later conduct selection work in H 109 and several promising seedlings. The selection work in D 1135 and Yellow Caledonia was done in two-year cane, the whole stalk being cut for seed, and the seed pieces being spaced three feet apart in the rows. All seed was soaked for several hours.

Onomea Sugar Company.

Individual plant and progeny performance record data have been obtained on the progeny test area planted at Papaikou in 1920. The following table will show the striking increase of selected cane over the unselected:

	Increase (unselected = 100%)		
	Stalks per Seed Piece	Stalks per Foot of Row	Tons cane per Acre *
68 selected progenies	162%	129%	130%
22 best selected progenies	202%	169%	157%
3 very best selected progenies	228%	189%	184%

* Tonnage is figured on the weight of the entire stick, including the seed pieces later removed for planting.

A gain was also noted in circumference and length of stalk, strength and rapidity of growth, and in the smaller amount of seed required for planting. In this case 20% was saved on seed alone, and it is hoped that this gain may be increased still more. Stools that were selected from crowded positions in the field maintained their supremacy over those from open positions; strains with a tendency to tassel the first year were noted; and those recorded as recumbent types last year produced very poorly this year and showed their greater liability to damage by cultivation, illiau, and rats.

By the use of the data so obtained, the best progenies were selected, and this selection checked up very closely with a general appearance selection. The very best stools in the best progenies were then taken for seed and planted in the test area, while the remaining seed in each progeny was bunched for planting. Next year data on tonnage yield per progeny will be obtained from four sources —yield on the plant crop of the best stools, yield on the plant crop of the remainder of each progeny, yield on the ratoons of the best stools, and yield on the remainder of the ratoons. To make these figures comparable with those of the present crop the seed was planted the same—spaced only three inches.

Many additional progenies have been planted at Papaikou, including Yellow Caledonia, Big Ribbon, and Black Tanna, numbering 512 in all, several of which stood out as distinct types.

Summary of Observations.

Since Mr. Shamel's departure and the publication of the report of the year's progress, much additional data have been obtained to show the inherent superiority of some parent stools and their progeny over others. Some progenies that have been obtained will yield as much in one year as the plantation fields will average in two, and others have been kept for study that were so inferior that one had difficulty in obtaining seed to continue the progeny through another crop. Does not this fact alone demonstrate the importance and necessity of selection to maintain high yields?

Distinct strains, mostly color and growth types, have been isolated that are so distinctly superior that they stand out like new varieties of cane. Constant association with and close study of the varieties are necessary if one is to become familiar with the types and strains as they grow in the field under different environmental conditions. More time should be spent on study of the progenies than on their cutting and planting.

There are many minor points to be considered along with the selection of the cane, such as the cutting of the seed, hardness of the stalk and of the eyes, the use of lala seed, number of eyes on the seed piece, sharpness of the knife, and the method of handling the seed prior to planting. All of these must be considered, as they may materially affect the results.

Conclusions.

(1)—Good seed is a determining factor in the production of maximum crops of sugar cane.

(2)—Good seed may be obtained by selection of superior stools, thus eliminating the unproductive and weaker strains.

(3)—Like produces like.
(4)—Certain inherently good stools maintain their superiority over others.
(5)—Types and strains exist and can be isolated.
(6)—Better and quicker germination of seed is obtained from superior parent plants.
(7)—More healthy stalks reach maturity and fewer dead shoots are found in selected progenies than in the ordinary run.
(8)—Better growth is maintained throughout the crop in selected canes.
(9)—Increased tonnage will result from proper selection.

But in all this work we must not overlook the value of seedling production, for in each variety that we have there is a strain that is the maximum yielding strain for that variety. The best strain of H 109 is probably better than the best strain of Lahaina, and there is no reason why we should not develop another seedling whose maximum will be higher than that of H 109. Our conditions here demand various constitutional varieties of cane, and these varieties are obtainable only through the growing of seedlings. These varieties having been established, then, by means of bud selection, we can isolate the superior strains. The seedling work and bud selection work go hand in hand—the first gives us our varieties of cane, and the second brings these varieties to their highest efficiency.

The Sugar Cane Beetle-Borer Parasite in Fiji.

Soon after the Tachinid parasite (*Ceromasia sphenophori*) of the beetle-borer was established in Hawaii, colonies were sent to Fiji, and for several years efforts were made to establish it, but apparently without any success, and at last all efforts were abandoned as hopeless.

Last year when working in the southeast portion of Fiji on the Rewa River, Mr. Pemberton found the parasite, and upon investigation it was discovered that about 30% of the beetle grubs were parasitized.

In a recent letter from Mr. Veitch, entomologist to the Colonial Sugar Refining Company, the following interesting paragraph occurs:

> "The Tachinid fly is now a very decided success on the Rewa, and this year borer at Nausori is almost a negligible quantity, a result that is very satisfactory after the bitter disappointment of previous years. . . . . . . In the establishment of the Tachinid parasite we now see substantial reward for all the money expended by the C. S. R., and in its success at Nausori Mill alone the saving effected is at the very least equal to ten times the annual expenditure on entomological research. For this we shall always be under a debt of gratitude to the H. S. P. A. for the excellent work done in discovering and introducing that parasite."

In the same letter is reported the first finding of *Placsius javanus*, a Histerid beetle introduced seven years ago from Java to Fiji to prey upon the banana-

borer, a beetle related to the cane-borer. It was considered that the colonies had died out, but the discovery of a specimen indicates that it has maintained itself for seven years, and it is possible that it will now increase gradually and be of economic importance. [F. M.]

Some Notes on Bud Selection of Sugar Cane.

In 1920 there was a cooperative investigation between A. D. Shamel and the men of this Station. A plan was arrived at, whereby we went through a field of cane ten to twelve months old, planted after the commercial fashion of Hawaii, and selected the stools of cane that showed in combination these points:

(a) More than the average number of stalks.
(b) Stalks of more than average size.
(c) A distinct uniformity as to the size and general character of the individual stalks.

These stools were cut and used as seed cane. Some of this work was done at Waipio. In order to avoid any gaps, only the seed cane in choice condition was employed in the planting. Some of the harder seed, thus discarded, was brought to Honolulu and planted in a small area at Makiki. This took place June 26, 1920. The cane that resulted was photographed August 23, 1921, after fourteen months' growth. The picture is shown herewith. The variety is H 109. In size, uniformity, and number of sticks this makes a very satisfactory appearance. Bear in mind that this is the product of the first crude selection. The yielding power of H 109 can be still further increased by singling out the best of the strains that compose the block of cane we have illustrated.[1]

From the plantings made in 1920 at Waipio a still further selection was made in April, 1921. Several progenies were planted at Makiki as single-eye cuttings. These were at first handled in pots and afterwards transplanted to the field and spaced at two-foot intervals. The best of the progenies so handled, No. 142, was planted alongside of the poorest, No. 15. (Not the poorest strain of H 109 to be found, merely the poorest of those which had in the beginning been selected as distinctly better than the run of the field.)

This cane in August was well stooled out, joints were beginning to show on a few stalks that were further advanced. There was visible a distinct difference between progeny 142 and progeny 15. No. 142 appeared to have greater uniformity. There were many good stools among No. 15, but there were also some poor ones. No. 142 showed no stools that were definitely poor.

We decided to record the difference between these two adjoining progenies by taking two rows of each and making detailed counts and measurements on 38 stools of each progeny.

[1] Soil comparatively new, only in cane a few years; fertilization low, one application August 26, 1920, supplied 51 lbs. of nitrogen; another, March 21, 1921, supplied 54 lbs. of nitrogen; irrigation normal.

H 109 cane grown from seed cane of stools selected on the basis of size, number, and uniformity of sticks. Planted June 26, 1920. Photographed August 23, 1921.

The average number of shoots per stool was about the same; 16.2 in No. 142 and 16.3 in No. 15. In the case of No. 142 this varied from 12 to 22, while in No. 15 the variation took the much wider limits of 7 to 30.

The length of the primary shoots of No. 142 averaged 34.3 inches, when measured from the ground to the last visible dewlap;[2] No. 15, 28.2 inches.

It is problematical at this time as to how much detailed attention can be devoted to recording measurements and characteristics of individual cane plants. However, for the benefit of those who may become interested in this phase of the work we have listed in tabular form the biometric data secured on these seventy-two stools of cane, progenies 142 and 15, there being thirty-six stools of each.

There were a number of different types of cane stools noticed in these and other progenies of the same age. Two of these stool types are pictured in Fig. 2. A represents the so-called nest type, where the suckers branch out at the surface of the ground, forming thereby a nest-like appearance. B shows a stool of an entirely different character, the suckers branching off at a greater depth and being usually more sturdy and uniform. We are inclined to favor this type of stool and have termed it the standard type. The diagrams shown below the pictures indicate the number, size, and position of the shoots in each of these stools.

A number of stools of different forms will be followed and their comparative merits judged when they are mature.

We believe that as the work proceeds we will learn to tell much about the value of a strain of cane by the general conformation of the stools when but a few months old. If this proves to be the case it will expedite the work of selection.

H. P. A.
J. A. V.
Y. K.

DATA COMPARING TWO STRAINS OF H 109 AFTER FOUR MONTHS' GROWTH.

	Progeny No. 142	Progeny No. 15
Character of stooling	6 deep	10 deep
	16 medium	19 medium
	14 shallow	7 shallow
	36	36
Shape of stool	11 fan type	20 fan type
	13 nest type	9 nest type
	6 standard type	4 standard type
	6 nondescript	3 nondescript
	36	36

[2] For illustrated definition of this term see Record Vol. XXII, p. 297.

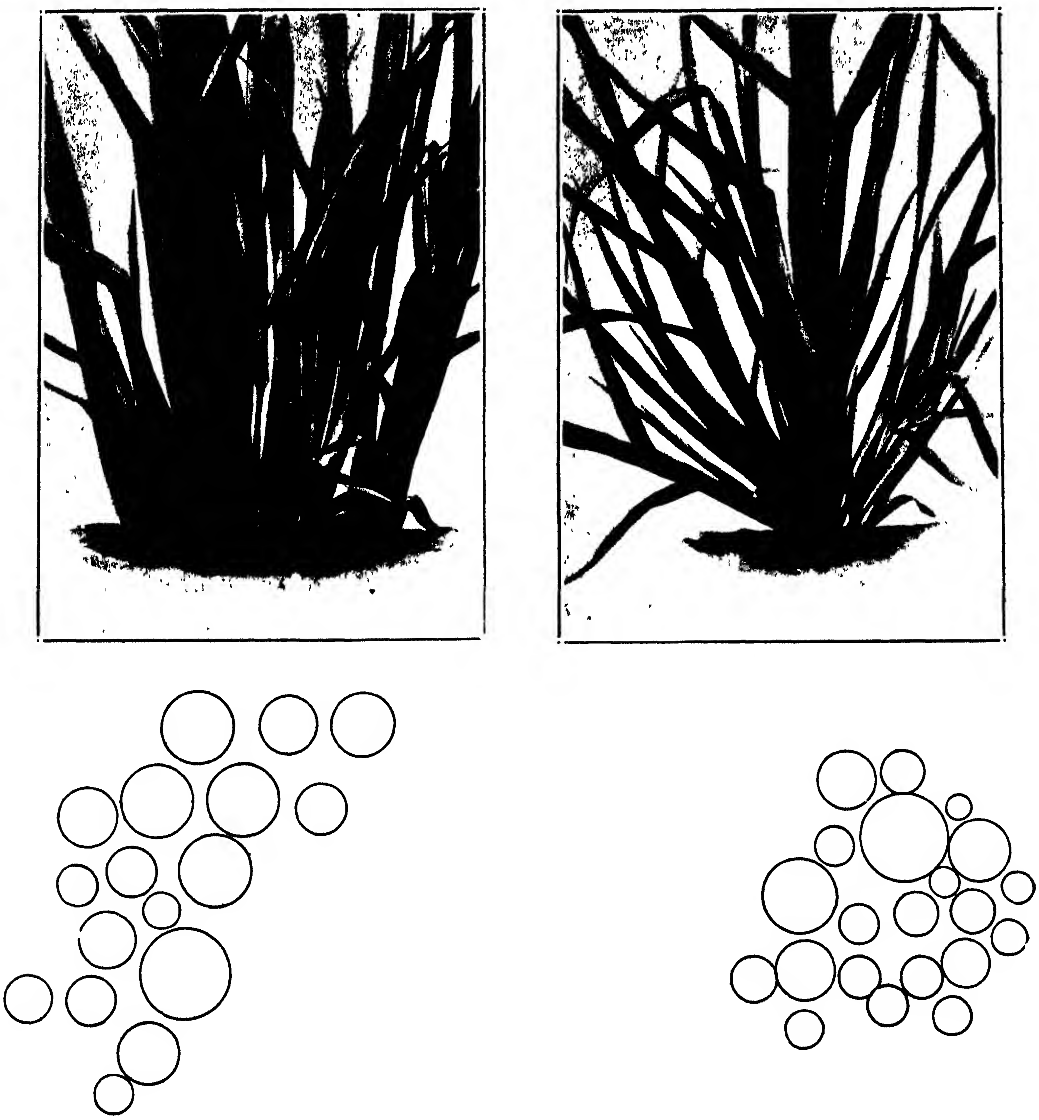


Fig. 2.—These two types of stools are found in selected H 109 cane planted from one-eye cuttings. The "nest" type shown at the right has shoots that branch off at the surface of the ground. In the "standard" type at the left the shoots are more deeply rooted. The diagrams below the pictures show the relative size, number, and position of the individual shoots.

Amount of purple on leaf sheaths	3 much	5 much
	25 medium	21 medium
	8 little	10 little
	—	—
	36	36
General uniformity of shoots with primary stick	2 high	8 high
	18 medium	19 medium
	16 low	10 low
	—	—
	36	36
General uniformity of sticks independently of primary stick	2 high	12 high
	27 medium	14 medium
	7 low	10 low
	—	—
	36	36
Length of primary shoot	0......15" to 20"	1......15" to 20"
	0......20" to 25"	9......20" to 25"
	5......25" to 30"	13......25" to 30"
	16......30" to 35"	11......30" to 35"
	13......35" to 40"	1......35" to 40"
	1......40" to 45"	1......40" to 45"
	1......45" to 50"	0......45" to 50"
Diameter of primary shoot	1.... ¾" to 1 "	4.... ¾" to 1 "
	29....1 " to 1¼"	31....1 " to 1¼"
	6....1¼" to 1½"	1....1½" to 1½"
	—	—
	36	36
Number of shoots of different lengths	33..... 0" to 5"	33...... 0" to 5"
	128..... 5" to 10"	140...... 5" to 10"
	231.....10" to 15"	250......10" to 15"
	82.....15" to 20"	84......15" to 20"
	51.....20" to 25"	36......20" to 25"
	21.....25" to 30"	8......25" to 30"
	2.....30" to 35"	1......30" to 35"
	—	—
	548	552
Number of shoots of different diameters ...	38...0 " to ¼"	40....0 " to ¼"
	270... ¼" to ½"	271.... ¼" to ½"
	117... ½" to ¾"	152.... ½" to ¾"
	90... ¾" to 1 "	79.... ¾" to 1 "
	32...1 " to 1¼"	9....1 " to 1¼"
	1...1¼" to 1½"	1....1¼" to 1½"
Average length of shoots	13.11 inches	12.13 inches
Average diameter of shoots	.546 inches	.502 inches
Average volume of shoots of stool	47.01 cu. in.	39.02 cu. in.
Uniformity factor, 1 representing perfect uniformity: Length	.6798	.6964
Diameter	.7049	.6417

A Dust Insecticide Against Leafhoppers.

By H. T. Osborn.

Considerable attention has been devoted in the past several years in insect control work to the application of insecticides and fungicides, in the form of a dust rather than a spray. Reports indicate that for some purposes the dust applications are fully as effective, and usually made more rapidly and at less expense, than the generally adopted sprays.

As a method of applying contact insecticides the use of dusts is quite recent. In 1916 it is reported that Mr. Ralph E. Smith successfully demonstrated the use of nicotine-sulphate in dust form, in the control of the Walnut aphis in California, using the formula, nicotine sulphate 2% in a carrier of kaolin, with 25% lime. The method proved so successful that dusting has entirely superseded spraying for the Walnut aphis, and in 1920 the Walnut Growers' Association made and distributed for this purpose 450 tons of the dust. Modifications of this formula have subsequently been tried out in California on a number of insects. Essig (Circular 223, University of California Agricultural Experiment Station, 1920), found that a 5% nico-dust gave fully as good results, and had many advantages over spraying for the Pear thrips. Also working in California, Mr. Roy E. Campbell (Circular 154, United States Department of Agriculture, 1921), has experimented with nicotine dusts and sprays against the Melon aphis, Cabbage aphis, Onion thrips, Pea aphis and Cucumber beetles, and summarizes his experience as follows:

> Dusting requires much less material, and may be done in a much shorter time, with a less expensive machine, and at about half the cost of spraying.
>
> The action of the dust is similar to that of nicotine-sulphate spray, but much more rapid.
>
> Nicotine-sulphate dust has proved superior to spraying for the Melon aphis, Cabbage aphis, Onion thrips, Cucumber beetles, and some other insects, giving usually a better killing at a smaller cost, and with greater speed and ease of application.

In view of these reports it seemed of interest to make some observations on the effect of nico-dust on the Sugar Cane Leafhopper. The dust used was one of the combined dusts manufactured by the Walnut Growers' Spray Manufacturing Company, of Los Angeles, and composed of not less than 5.9% nicotine-sulphate, 44% inert carrier, and 50% sulphur dust. It was applied with a hand duster. The spray used for comparison was used at the strength found satisfactory by Mr. Pemberton, nicotine-sulphate 1 part, to water 1000 parts, with about 2 lbs. whale oil soap to each 50 gallons water. An ordinary knapsack sprayer was used in application.

The tests with the nico-dust were made in field No. 13A, at Ewa plantation. This was H 109 cane, planted in December, 1920, and had made so large a growth as to make the dusting and spraying a difficult matter, but at this time no fields of smaller cane could be found which were sufficiently infested to be used in this

work. Field No. 13 has been observed to be quite free of hoppers until June and July, when a slight infestation began to develop over a small part of the field. Adults were present in fair numbers, sufficient to cause some blackening of the cane in this small area in the first part of July, but on July 21 had largely disappeared. A brood of newly hatched nymphs was present, however, in quite large numbers.

The first trial of the dust was made on July 21. In order to get some idea of the effectiveness of the dust and sprays, strips of cloth five feet in length were placed on each side of a cane row, and the hoppers falling thereon were collected and counted.

The result of the dusting on July 21 was:

Adult hoppers	25
Nymphs	2,300

The nymphs at this time were very small, and an examination of the cane after dusting disclosed a few still apparently not affected.

In the curled up spindles from 15 to 20 nymphs had escaped the dust.

On July 27, six rows were sprayed and six rows were dusted. The resulting kill per five-foot row apparently was:

Dusted:	Adults	142	Sprayed:	Adults	23
	Nymphs	5,800		Nymphs	2,200

On August 2, a five-foot distance in both these plots was dusted to determine the number present a week after the first treatment.

From plot previously dusted:		From plot previously sprayed:	
Adults	151	Adults	319
Nymphs	550	Nymphs	1,350

On August 3, three rows were dusted and three rows were sprayed. No counts were made at the time, but a five-foot distance in both plots was dusted August 11 to determine the number present a week after treatment.

From plot previously dusted:		From plot previously sprayed:	
Adults	69	Adults	262
Nymphs	200	Nymphs	304

By August 11 the nymphs were half grown or more, and very few newly hatched ones were present. Newly matured adults were also appearing. Three rows were dusted and three sprayed. The result was:

Dusted:	Adults	761	Sprayed:	Adults	230
	Nymphs	967		Nymphs	373

On August 17, a five-foot distance in both these plots was dusted to determine the number present after treatment.

From plot previously dusted:		From plot previously sprayed:	
Adults	160	Adults	290
Nymphs	150	Nymphs	150

On August 17, distances of five feet along the rows were dusted with the following results:

From plot dusted July 27:		From plot sprayed July 27:	
Adults	190	Adults	561
Nymphs	33	Nymphs	362

From plot not previously treated.	
Adults	524
Nymphs	496

Remarks.

It will be seen from the counts above that the dusting gave a rather better kill in the plots than the spraying at the strengths used. The counts made on the first application, however, are somewhat misleading, in that the dust appeared to act faster, and once a hopper fell onto the cloth it was apt to be overcome, partly from the dust that had settled there. With the spray, on the other hand, the hoppers would continue to move about, and perhaps were not so apt to be caught on the cloth. Also the hoppers appeared to be rather unevenly distributed, which interferred with a very accurate comparison. The check treatments made a week or more later gave a much better comparison. The adult hoppers no doubt move back on the treated plots, but the nymphs killed in subsequent treatment would seem to indicate the relative effectiveness, as very few newly hatched ones appeared after July 27th. In every case it will be noted that fewer nymphs were secured in the checks on plots that had been dusted than on those that had been sprayed. It should also be noted that the total number of hoppers secured from an equal distance on previously untreated cane on August 17th was less than one-fifth the number secured from a like distance on July 27th, which would seem to indicate an enormous natural mortality in the developing nymphs.

The fact that the dust remained on the leaves for several weeks after the treatment may in part explain the smaller number to be found on those plots later, as there may be some repellent value in the dust.

To make an accurate estimate of the relative expense of the two methods from an experiment on such a small scale would be very unsatisfactory. It was possible in the cane worked in to dust thoroughly about three times as fast as to spray. In dusting, a considerable amount of waste in the application of the material occurred, the application being at the rate of from 100 to 125 pounds per acre roughly. The spray was applied at the rate of over 300 gallons per acre. The area of cane treated, as well as the amount of material required, would vary very widely according to the size of cane being treated. From the time required in applying to these very small areas, it was estimated that one man might dust as much as an acre and a half or two acres in a day.

Effect on Parasites.

In examining the material collected from the sprayed and dusted plots, small numbers of insect predators, spiders, were obtained, though in general these appeared to be resistant.

In only one case were the leafhopper egg parasites found in numbers. The

dusted plot July 27 showed 80 *Ootetrastichus beatus,* 50 *Ootetrastichus formisanus,* and 270 of the Mymarid parasites. The same plot August 2 yielded 90 *Ootetrastichus beatus,* 26 *Ootetrastichus formisanus,* and 100 Mymarids.

Concluding Remarks.

During the present season the infestation by leafhopper at Ewa, as well as on the other plantations on Oahu, has been so light that the need for any artificial control would seem to be very slight. In seasons of heavier infestation, or in other localities, a series of experiments might be conducted to determine the practical value as determined by an increased yield sufficient to justify expense involved. Observations at Ewa during the past year would seem to indicate that the infestation in cane, small enough to be easily worked in, is usually light or of short duration, the heavier infestations usually being in fields of six months to a year's growth, where the difficulties of any artificial control are greatly increased.

Boiler Explosions in the United States During 1920.*

The year 1920 produced the largest number of boiler accidents so far recorded. The total accidents amounted to 652, which is greater by 102 than the largest previous year, 1909, when the number was 550. The number of persons killed and persons injured has, on the other hand, fallen below the average figure of recent years, 1920 showing a total of 137 killed and 262 injured.

The monthly figures for number of accidents, persons killed, persons injured, and total of killed and injured are given in the table below.

SUMMARY OF BOILER EXPLOSIONS FOR 1920

Month	Number of Explosions	Persons Killed	Persons Injured	Total of Killed and Injured
January	86	13	27	40
February	66	12	20	32
March	53	9	23	32
April	47	12	9	15
May	36	5	11	16
June	31	8	21	29
July	41	16	22	8
August	36	5	29	34
September	42	15	25	40
October	53	17	15	32
November	87	18	22	40
December	74	7	38	45
Totals	652	137	262	399

[W. E. S.]

* From "The Locomotive."

High Temperature Bacteria in Hawaiian Sugar Factories.

By C. W. CARPENTER *and* H. F. BOMONTI.

The experiments of H. S. Walker and A. Fries, cited in the 1920 report[1] of the committee on juice deterioration indicate that bacteria are active in hot juices. In this report W. R. McAllep states that while no investigation has been made in Hawaii to detect the presence of high temperature organisms, there are strong indications that such organisms are present in our mills. The reader is referred to the committee report for the detailed discussion of the experiments, which have led to the investigation herein reported.

THERMOPHILIC BACTERIA.

Bacteria capable of growth at temperatures above 50° C. (122° F.) are called thermophilic bacteria. These bacteria were discovered by Miquel in 1879, and since then have been reported upon by various investigators. They are frequent inhabitants of the waters of hot springs, but are also surprisingly common in soil, manure, surface waters, etc. Many of them are spore formers and by means of these spores are capable of standing boiling temperatures for some time. Since they are incapable of growth at ordinary temperatures, but in general start at temperatures above 40° C. (104° F.), with their optimum often between 60° and 70° C. (140°-158° F.), it is a subject of conjecture as to where in nature they find opportunity for development. It is thought that much of their development takes place in association with the thermogenic or heat producing bacteria in decaying organic matter.

As to the occurrence of thermophiles in mill juices, the literature is very scanty. Shöne[2] records one group of bacteria whose optimum temperature for growth is said to be 50° C. (122° F.). D. S. North, in unpublished studies, seems to have been one of the first to recognize the significance of these bacteria to sugar manufacture. In general mycologists and bacteriologists have investigated in sugar products only those micro-organisms which are associated with the deterioration of stored sugars at ordinary temperatures.

In the investigation reported below, the results of a preliminary survey of the deterioration of hot clarified juice by bacteria are recorded. In this investigation the senior author has handled the bacteriological work and the junior author the chemical studies.

DETERIORATION DUE TO THERMOPHILIC BACTERIA IN HOT JUICES.

First an attempt was made to demonstrate the existence of active bacteria in clarified juice at temperatures above 60° C. (140° F.). Following success in this matter the bacteria were isolated and cultivated at these temperatures (60°–

[1] Report of the committee on juice deterioration. In Hawaiian Planters' Record, Vol. XXIV, No. 5, p. 198–203, 1920.

[2] Shöne, Albert. De microorganismen in de sappen der Suikerfabrieken. *In* Archief voor de Java Suikerindustrie, Vol. XI, 786–801, 1905. Abstract. Intern. Sugar Journ., Vol. VII, p. 523–526.

70° C.); experimental inoculations of sterile juices and sugar solutions were made, and the latter incubated under carefully controlled conditions. In the beginning the cultures and flasks of inoculated solutions, etc., were incubated in electric incubators, but it was soon found that the temperatures varied considerably in different parts of the chambers. To insure accurate temperature control a water-jacketed incubator with an inner water bath in which the cultures could be immersed was arranged. The temperature of the water bath was constantly recorded with a Bristol thermometer whose sensitive bulb was completely immersed therein. This thermometer was accurately adjusted to correspond with a mercurial thermometer tested by the Bureau of Standards. The temperature in different parts of the bath was found to vary less than one-half degree centigrade.

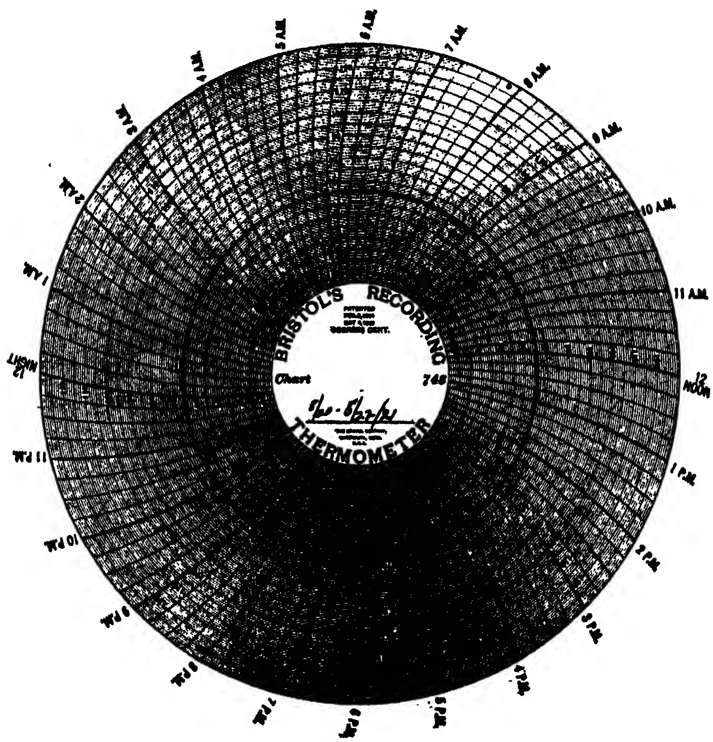


Figure 1.—Temperature chart from the Bristol recording thermometer, showing the incubation temperatures over a 48-hour period.

A quantity of mixed juice was obtained from a nearby plantation. Two-hundred c.c. portions were placed in Erlenmeyer flasks, each portion being then limed with 0.75 c.c. of milk of lime. One set of flasks was sterilized in an autoclave at 30 pounds pressure (130° C.); another set was brought to a boiling temperature; some flasks of both sets were then incubated at the following temperatures: 50°, 60°, 70°, and 80° C. (122°, 140°, 158°, 176° F.). After incubation periods of 18 and 42 hours the juices were analyzed, the results being shown in Table I, where purity indicates apparent purity, which is Pol. / Brix.

TABLE I—DETERIORATION OF BOILED JUICE AND STERILE JUICE.

Hours	50° C.				60° C.			
	Boiled Juice		Sterile Check		Boiled Juice		Sterile Check	
	Purity	Decrease	Purity	Decrease	Purity	Decrease	Purity	Decrease
0	88.94	....	86.65	....	88.94	....	86.65	....
18	88.95	+ 0.01	86.33	0.32	88.35	0.59	85.89	0.76
42	86.47	2.47	85.63	1.02	84.47	4.47	85.34	1.31
	70° C.				80° C.			
0	88.94	....	86.65	....	88.94	....	86.65	....
18	88.55	0.39	86.15	0.50	85.91	3.03	84.14	2.51
42	83.83	5.11	83.82	2.83	84.26	4.68	78.62	8.03

This experiment gave strong indication that there was bacterial growth as high as 70° C. There is a marked difference in decrease in purity between the juices sterilized and those only brought to the boiling point. It was found that duplicate checks (sterilized) incubated at 80° C. varied as much as 10 points, and for this reason the results at this temperature must be disregarded. At the other mentioned temperatures the duplicate analyses agreed closely.

The juices in the above experiment were filtered with kieselguhr through hardened filter paper. Examination of these filtered juices failed to show the presence of bacteria, and it is our experience that such filtration of juices after shaking up with kieselguhr removes the greater number of the organisms. In the following experiment the juices which had been heated only to boiling and incubated showed a large number of bacteria before filtering.

The experiment, the results of which are shown in Table I, was repeated at approximately 65° and 75° C. The results of the analyses are shown in Table II.

TABLE II—DETERIORATION OF BOILED JUICE AND STERILE JUICE.

Hours	65° C.					
	Boiled Juice			Sterile Juice		
	Reaction:[1] Per Cent CaO	Purity	Decrease	Reaction: Per Cent CaO	Purity	Decrease
0	.014 alk.	83.36	....	.014 alk.	82.39	....
22	.040 acid	80.42	2.94	.020 acid	82.12	0.27
46	.072 acid	75.97	7.39	.030 acid	81.80	0.59
	75° C.					
0	.014 alk.	83.01	....	.014 alk.	82.46	....
22	.030 acid	81.46	1.55	.020 acid	82.07	0.39
46	.055 acid	76.57	6.44	.030 acid	79.92	2.54

[1] Reaction determined with litmus as indicator.

In this experiment there are the same decreases in purity as shown in Table I. The two experiments showed that bacteria were probably responsible for the deterioration noted, and thermophilic organisms were promptly isolated by the poured plate method, incubation being carried on in a moist chamber at 65° C. (149° F.). Inoculation experiments were then inaugurated to determine, if possible, the effect of these organisms in hot juices.

In one experiment six 100 c.c. volume flasks were sterilized. Clarified juice was shaken up with kieselguhr and filtered aseptically. Into each flask 75 c.c. of juice was pipetted. A sample of the juice was also taken for immediate chemical analysis. The six flasks of juice were then heated to 65° C. in a water bath, and three inoculated with one c.c. of a 48-hour culture on bouillon. The other three received the same amounts of sterile bouillon. The inoculated and control flasks were then incubated at 65° C.

The results of this inoculation experiment are given in Table III.

TABLE III—COMPARATIVE ANALYSES OF INOCULATED JUICE AND STERILE JUICE.

Hours at 65° C.	Purity of Inoculated Juice	Reaction:[1] Per Cent CaO	Decrease in Purity	Purity of Sterilized Control	Reaction: Per Cent CaO	Decrease in Purity
0	78.57	.019 acid	....	78.57	.018 acid	....
16	78.00	.030 acid	0.57	78.57	.020 acid	....
40	75.32	.035 acid	3.25	78.45	.024 acid	0.12
64	73.43	.040 acid	5.14	78.40	.025 acid	0.17

The acidity of the inoculated juice increases very rapidly, accompanied by a decrease in purity amounting to 5.14 in 64 hours. The control juice slightly increases in acidity, while the purity remains nearly constant with a decrease of but 0.17 after 64 hours.

The appearance of the inoculated juice is in marked contrast to the uninoculated. The latter remained clear and bright and of brownish red color throughout incubation, while the former was turbid in 24 hours and of a yellowish color. The inoculated juice also has a fermented acid odor, while the control retains the characteristic odor of the original juice. Similar results were obtained with clarified juice from another mill.

In several additional experiments with clarified juices and sugar solutions the results indicated the destruction of dextrose after inversion of the sucrose. A typical example of this action is shown by the analyses recorded in Table IV. Clarified juice sterilized in flasks at ten pounds pressure for fifteen minutes was used.

[1] Reaction referred to phenolphthalein as indicator.

TABLE IV—COMPARATIVE DATA ON STERILE JUICE AND INOCULATED JUICE.

	Sterile Juice	Inoculated Sterile Juice
Original apparent purity	82.18	82.18
Original reaction (%CaO)	.015	.015
After 36 *hours at* 65° *C.*		
Reaction	.018	.036
Apparent purity	82.07	80.52
Gravity purity	83.33	82.56
Invert sugar	0.64	0.65

In the above experiment by gravity purity we mean $\frac{\text{Sucrose (Clerget)}}{\text{Brix}}$; sucrose was determined by the method outlined in "Methods of Hawaiian Chemists' Association."

The difference between the gravity purity and the apparent purity of the sterile juice is 1.26, while in the inoculated juice the difference between the gravity purity and the apparent purity is 2.04. With practically the same per cent of invert sugar we would expect these differences to be the same. It seems very probable that the invert sugar of the inoculated clarified juices consists of a larger per cent of levulose than that of the sterile check. This would account for the larger difference between gravity purity and apparent purity. We recognize the possibility that invert sugars are precipitated by Horne's dry lead, which might account for the differences mentioned, if we had not obtained similar results with sugar bouillon solution where no lead was used for clarification. This seems to indicate that dextrose is destroyed.

We believe that this organism destroys invert sugar forming an organic acid. This acid at the high temperatures 60°–75° C. (140°–167° F.) inverts sucrose forming more invert sugar. The acidity of the deteriorated juice does not increase beyond the equivalent of 0.050 per cent CaO, referred to phenolphthalein as an indicator.

The bacteriological studies failed to show any bacteria capable of growth at temperatures above 73° C. (164° F.).

Nature of the Thermophilic Bacteria of Mill Products.

Bacteria capable of growth at temperatures from 45° to 73° C. have been isolated in our investigations from hot juice from the filter presses, clarified juice, sugar from the centrifugals as well as the final product, and from the Experiment Station tap water. In one attempt such organisms were not detected in refined sugar from the granulator.

Thirty-eight samples of raw sugar from as many factories collected in routine sampling were examined as follows for the presence of thermophilic bacteria: Plugged culture tubes were sterilized at 19 pounds pressure for fifteen minutes in the autoclave; into each was poured about one gram of sugar. About ten c.c. of sterile distilled water was added to each tube with a sterile pipette and the tubes heated in a steamer at about 99° C. for one-half hour. The tubes

of sugar solution were then incubated at 62° C. (144° F.). Microscopic examination the following day showed bacteria present in all samples; whether these were living thermophiles in every case is somewhat doubtful since when transfers from these tubes to bouillon were incubated at 62° C. but 26 out of the 38 grew in 24 hours. The presence of growth was judged by the clouding of the medium.

These samples of raw sugars were taken in unsterilized containers and they were exposed to the possibility of bacterial contamination one to another before they were obtained for the tests above described. We cannot state that these high temperature bacteria are present in all mills, but the evidence supports the view that they are widely distributed.

Morphologically the various cultures made have not been studied to the point where we can express an opinion as to whether we are dealing with one species or with a group of bacteria. The preliminary work indicates that there are at least varieties present rather than a single constant species.

The particular strain of thermophilic bacteria on which the following notes are based does not agree in its morphology with any named species, though it must be said that the descriptions of bacteria of this sort are in general too meagre to allow identification. The characters of the organism which are likely to be of practical benefit, as well as certain salient features which may serve for identification purposes are recorded below. Since this organism cannot be definitely identified with any previously named species, the name *Microspira Northii* is proposed, which suggests D. S. North, who has in unpublished work dealt with a similar, if not identical, form.

This organism takes the form of short rods (2.5–4.0 μ), long rods (4.5–8.0 μ), and interwoven chains of great length. The diameter varies from 0.75 to 1.5 μ, in the same preparation. The rods appear straight, or nearly so, but careful examination shows a slight curvature of the longer rods and chains, with **S** forms and spirals rather infrequent. The great variation in diameter of the rods and relatively infrequent **S** forms suggest a mixed culture, but the two types have not been separated by repeated platings. Therefore the organism must be classed in the genus *Microspira* of *Migula*, characterized by slightly curved rods and **S** forms. The rods are motile by means of three to ten or more trichiate[1] flagella (Plate I) of great length. Sluggish motility continues for several minutes after the preparation cools to room temperature. Flagella were demonstrated by means of a modified Loeffler's method, with carbol-fuchsin or anilin water gentian violet as the final stain.

The organism grows well on slightly acid bouillon and bouillon agar. The presence of sugar in the bouillon or agar does not seem to insure a better growth. No growth occurred in synthetic media tried, such as Uschinski's, Fermi's, and Cohn's solutions with sucrose added.

The colonies (text figure 2) on bouillon agar appear in 24 hours at 65° C.; in two to three days they are from two to five millimeters in diameter. Surface colonies are smooth, rounded, entire, and pearly white in color. Buried colonies are more irregular in appearance, with short processes of chains invading the medium. In the surface colonies we find shorter and thicker rods, while in the

[1] Not restricted to any particular part of the organism.

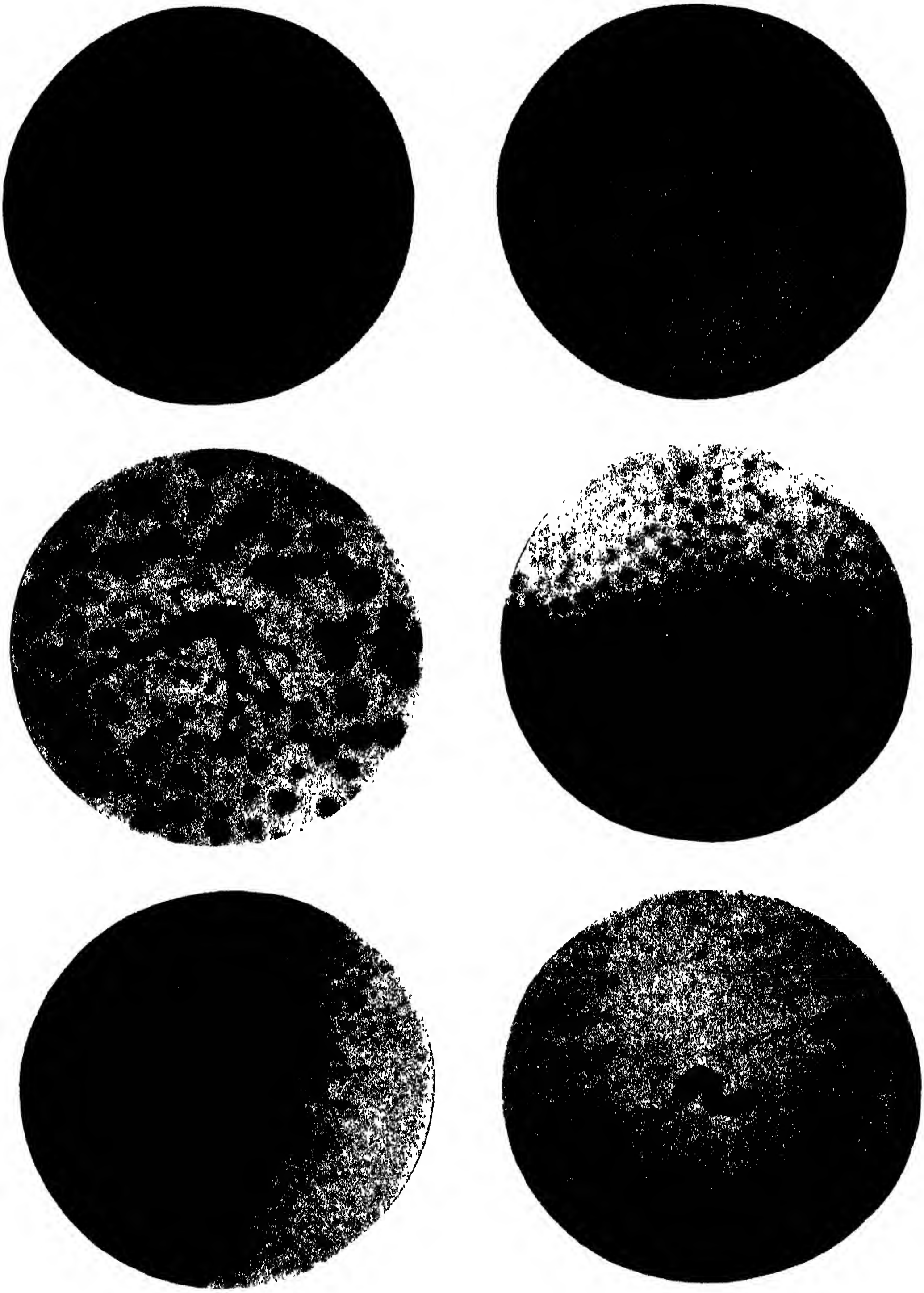


Plate I.

Microspira Northii nov. spec. $\times$ 2000.

All the bacteria illustrated in the six figures were stained by Loeffler's method for flagella.

Fig. 1. A long curved rod form with peritrichiate flagella.

Fig. 2. Spore forming long rod form or short chain bearing flagella.

Fig. 3-4. Short rod forms with peritrichiate flagella.

Fig. 5-6. Short and long S forms.

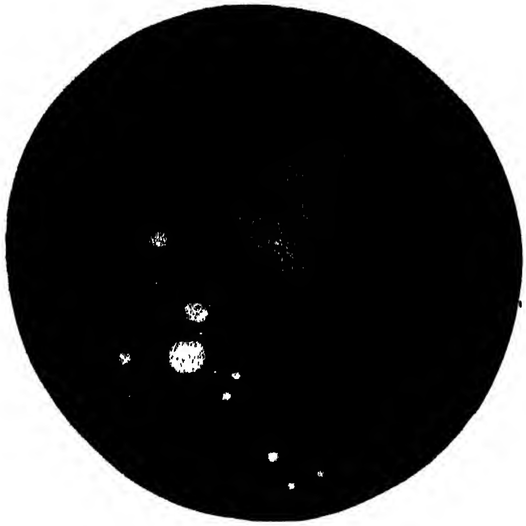


Figure 2.—Colonies of **Microspira Northii** nov. spec. on standard bouillon agar. Incubated three days at 65° C. (149° F.). × 3/5.

buried colonies we find long, thin chains. The growth on agar indicates preferment for plenty of oxygen.

On bouillon medium a distinct, though rather moderate, clouding can be detected in 24 hours or less at 65° C. in the upper portion of the liquid, and if the tube be inclined, a thin, flaky pellicle (scum) is to be noted. This becomes more conspicuous with age and settles as a flaky precipitate. No change in color of either agar or bouillon was detected except that the increasing turbidity in bouillon makes the medium lighter in appearance.

Spores may be formed in less than 24 hours, and are detected by the egg-shaped swelling in the center of the rods. They may be readily seen without the aid of stains. The spores measure about $2.5 \times 3.0\ \mu$ and are readily demonstrated by staining with carbol-fuchsin. Rods which are possibly short chains are often seen moving actively with a spore at or near the center. The writers could never be certain that single cells acted in this manner, but considered it probable that in short chains of two or more elements younger cells were actively motile while a mother cell had formed a spore. Flagella on a spore forming short chain (?) are illustrated in Plate I, Fig. 2. These spores stand boiling for some time at least, but in our experience may be killed by steaming at 15 pounds pressure for fifteen minutes. The bacteria remain unstained by Gram's method. The organism on culture media did not show a special predilection for sugar, either sucrose or dextrose. It did not form gum. A moderate amount of gas was liberated in sugar bouillon:

The minimum temperature for growth was 46° C., since at this temperature no growth occurred in 24 hours, but a scanty growth was to be detected in 48 hours. The maximum temperature at which growth has been detected was at 73° C. (164° F.). The optimum temperature is from 65° to 70° C. Another strain but slightly studied has a somewhat lower minimum as well as maximum

temperature for growth. No growth was secured in culture media with a concentration greater than about 25° Brix, cane sugar being added to bouillon.

As above noted this thermophile is somewhat anomalous in its characters. Most thermophilic bacteria are non-motile. Motile thermophilic bacteria have, however, been mentioned by Shöne (l. c.), Falcioni[1] and Georgevitch[2], the two latter having worked with bacteria from hot springs. Our organism is not only motile, but has some spiral forms, though no flagella were detected on strictly spiral forms, which are rather rare. Motile spiral bacteria normally have one or more polar flagella and sometimes a bipolar arrangement of the flagella. In contrast we have a motile thermophile with apparent relation to the genus *Microspira*, but with a peritrichiate arrangement of flagella, an anomalous condition which renders further careful work necessary before its classification can be satisfactorily determined.

Microspira Northii nov. spec.

Vegetative cells are short and long rods with rounded ends; short rods 2.5 to 4.0 μ, long rods 4.5 to 8.0 μ. Chains of varying length and diameters. The diameter of the elements varies from 0.75 to 1.5 μ. Rods straight to slightly curved with S forms, short and long spirals infrequent. Irregular orientation in general the chains being interwoven particularly in buried colonies; occasionally surface colonies show a parallel arrangement of the elements. The rods are motile by means of three to ten or more paritrichiate flagella several times the length of the rods.

Central egg-shaped endospores, measuring 2.5 x 3.0 μ, are formed in less than 24 hours, the spore bearing elements often continuing actively motile. Capsules were not detected. The rods are readily stained with either carbol-fuchsin or gentian violet. Flagella were demonstrated with a modified Loeffler's method and either carbol-fuchsin or anilin water gentian violet for the stain. The cells remain almost entirely unstained by Gram's method.

This organism is aerobic and grows well in 24 hours on standard bouillon and bouillon agar. On bouillon a moderate clouding and fragile pellicle are evident in 24 hours at 65° C. At the same temperature on agar a filiform, raised, entire, pearly white, smooth, glistening growth appears in 24 to 48 hours. Agar colonies are rounded, raised, entire, pearly white, smooth and glistening. Buried colonies are more irregular with short processes of intertwined chains. Gas formed in sugar bouillon as evidenced by sufrace bubbles; none detected in fermentation tubes with clarified juice. Acid formed in sugar bouillon and clarified juice. No gums were detected.

No growth occurred on any synthetic medium tried. Cohn's, Uschinski's and Fermi's solutions with sucrose added weie among those used. One strain of thermophile grew on these media, indicating varieties among thermophiles of sugar factories.

Concentration of the medium: No growth was detected in sugar bouillon with a concentration greater than 25 Brix.

Temperature relations: Optimum temperature for growth 65° to 70° C. Maximum temperature for growth, 73° C. Minimum temperature for growth, 46° C.

Classification: The morphology of the particular strain of thermophile studied was somewhat anomalous with respect to systems of classification. The

[1] Falcioni, D. I germi termofili nelle acque del Bullicame (Arch. de farmocol. sperm. 1907, No. 1.) *In* Centralb. f. Bakt. Bd. XX, p. 164, 1907.

[2] Georgevitch, Peter. *Bacillus thermophilus* Jivöini *nov. spec.* and *Bacillus thermophilus* Losanitchi *nov. spec. In* Centralb. f. Bakt. Bd. XXVII, p. 150–167. 1 pl. 1910.

organism is a motile spiral thermophile with peritrichiate flagella. The name *Microspira Northii* is proposed for this organism, suggesting D. S. North, who has discussed in unpublished studies a high temperature organism in sugar factories.

SUMMARY.

1. Bacteria capable of growth at temperatures from 46°-73° C. (115°-164° F.) are common inhabitants of mill products.

2. Such bacteria were detected in juice from the filter presses, clarified juice in the settling tanks, in sugar from the centrifugals and bagging machine. Similar thermophilic bacteria were also detected in the Experiment Station water supply.

3. Thermophilic bacteria isolated from clarified juice were found to be acid formers and capable of bringing about inversion of sucrose at temperatures from 50° to 70° C. (122°–158° F.).

4. The strain particularly studied destroys sucrose by acid inversion, forms no gum, in the spore stages withstands boiling an undetermined time, and grows in solutions with concentrations up to 25° Brix.

5. These thermophiles are motile, spore forming rods of varying lengths and diameters; curved **S** and spiral forms occur occasionally.

6. This selected strain is provisionally called *Microspira Northii* nov. spec., its morphology being somewhat anomalous with respect to systems of classification.

A Phosphoric Acid Test.

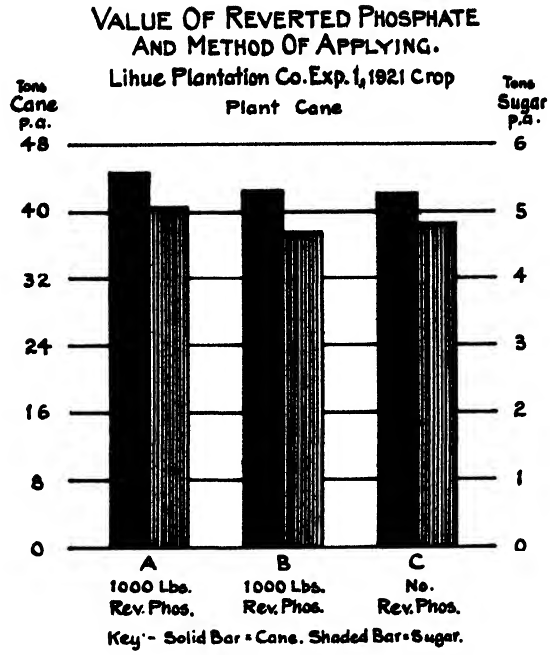
LIHUE PLANTATION EXPERIMENT NO. 1, 1921 CROP.*

This experiment was planned to determine the value of phosphoric acid, and to compare the time and method of application on the makai lands of the Lihue District.

Reverted phosphate was applied at the rate of 1000 pounds per acre. In one case it was applied broadcast and harrowed in before furrowing; while in the other it was applied in the furrow with the seed; in a third series of plots no phosphate was applied. All plots received a uniform dose of 125 pounds of nitrogen per acre. The cane was Yellow Caledonia plant in a field which had been fallowed for one year. The trash from the previous crop was plowed in and stock was pastured on the field during the period of fallowing.

The results show no definite gain for the phosphate. While the average yield for the reverted phosphate harrowed in shows a slight increase over no phosphate, the increase is so small as to be within the limits of experimental

* Experiment planned and laid out by R. S. Thurston. Results calculated by J. A. Verret and Y. Kutsunai.



error. On the other hand, phosphate with the seed shows no increase over no phosphate. The following tabulation shows the treatments and yields.

Plot	Treatment	Tons per Acre		
		Cane	Q. R.	Sugar
A	Reverted phosphate harrowed in	44.67	8.83	5.06
B	Reverted phosphate with seed	42.39	8.99	4.72
C	No phosphate	42.03	8.71	4.83

This negative response of cane to phosphate fertilization corroborates experiments conducted on Grove Farm plantation in this same type of soil. This lack of response of these makai soils is in marked contrast to the mauka soils, which respond very profitably to phosphate.

This experiment is to be repeated to note any possible effect on ratoons.

DETAILS OF EXPERIMENT.

Object:

(1) Comparing broadcasting and harrowing in before planting with applying in furrow with seed.

(2) Value of.

Location:

Field 1.

Crop:

Yellow Caledonia, plant cane.

Layout:

Number of plots: 26.

Size of plots: 1/10 acre each (108′ x 40.3′), composed of 24 straight lines one watercourse long. Rows 4.5′ x 40.3′.

Plan:

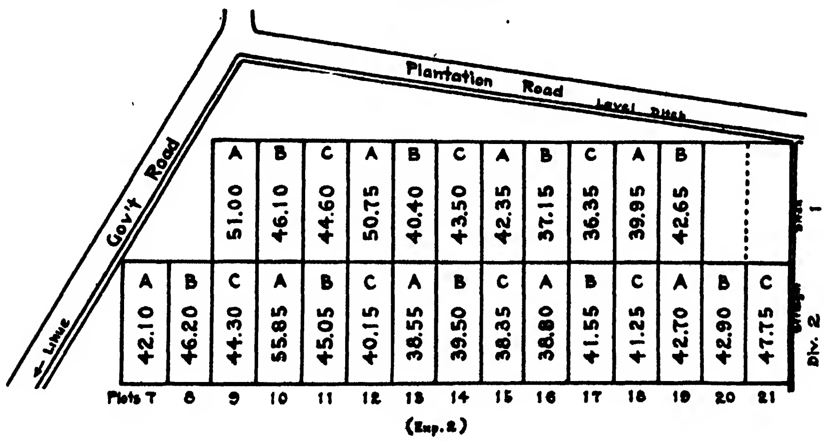
Plots	Number of Plots	Treatment
A	9	1000 lbs. per acre reverted phosphate applied broadcast and harrowed in before furrowing.
B	9	1000 lbs. per acre reverted phosphate applied in furrow at time of planting.
C	8	No reverted phosphate.

All plots to receive uniform fertilization in form of nitrate of soda. Amount to depend on appearance of cane.

VALUE OF REVERTED PHOSPHATE AND METHOD OF APPLYING.

Lihue Plantation Co. Exp. 1, 1921 Crop

Plant Cane



Summary of Results

Plot	No. of Plot	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	9	1000# Reverted Phosphate per acre broadcast + harrowed in.	44.67	8.83	5.06
B	9	1000# Reverted Phosphate per acre applied in furrow.	42.39	8.99	4.72
C	8	No Reverted Phosphate	42.03	8.71	4.83

PROGRESS OF EXPERIMENT.

April 2-10, 1919—Experiment laid out.
April 12, 1919—Applied phosphate to A plots.
April 23, 1919—Applied phosphate to B plots.
June 5, 1919—Staked.
Setember 12, 1919—Erected signs.
March 4, 1920—Fertilized with nitrate of soda.
April 1-23, 1921—Harvested by J. H. Midkiff.

R. S. T.

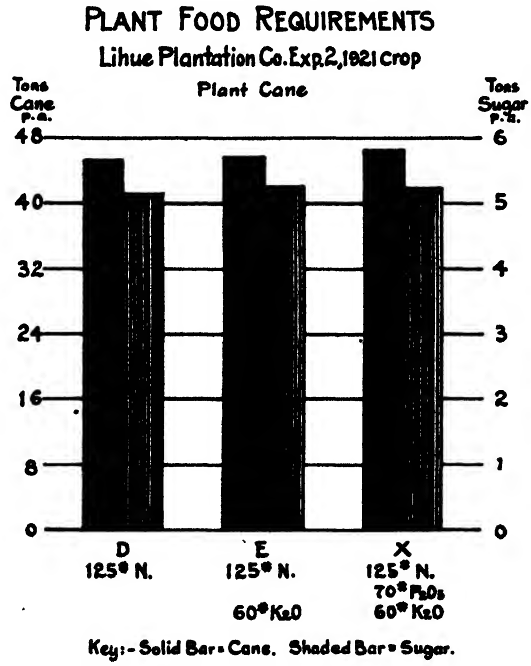
Phosphoric Acid and Potash at Lihue.

LIHUE PLANTATION — EXPERIMENT 2, 1921 CROP.*

The object of this experiment is to determine whether the makai soils of the Lihue district need phosphoric and (or) potash in addition to nitrogen.

All plots received a uniform dose of 125 pounds of nitrogen per acre. The E plots received, in addition to the nitrogen, 60 pounds of potash, while the X plots received 70 pounds of phosphoric acid and 60 pounds of potash per acre.

The cane is Yellow Caledonia plant on land which was fallowed one year. The trash from the previous crop was plowed in, and the field was pastured to stock during the fallow period.



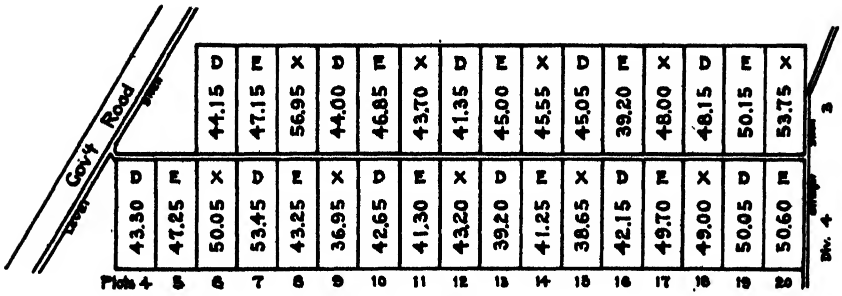
The variation in yield between the different treatments is so slight as to be within the limits of experimental error. In other words, the presence or absence of either or both phosphoric acid and potash makes no difference in the yields. The following tabulation shows the treatments and yields.

Plot	Fertilization—Pounds per Acre			Yield in Tons per Acre	
	N	P_2O_5	K_2O	Cane	Sugar
D	125	0	0	45.23	5.15
E	125	0	60	45.61	5.24
X	125	70	60	46.58	5.22

This experiment is to be repeated to note possible effect on ratoons.

* Experiment planned and laid out by R. S. Thurston. Results calculated by J. A. Verret and Y. Kutsunai.

PLANT FOOD REQUIREMENTS
Lihue Plantation Co. Exp. 2, 1921 Crop
Plant Cane



(Exp. 2.)

Summary of Results

Plots	No. of Plots	Treatment			Yields Per Acre	
		Nitrogen	P_2O_5	K_2O	Cane	Sugar
D	11	125	0	0	45.23	5.15
E	11	125	0	60	45.61	5.24
X	10	125	70	60	46.58	5.22

DETAILS OF EXPERIMENT.

Object:

To determine the need of phosphoric acid or (and) potash.

Location:

Field 1.

Crop:

Yellow Caledonia plant, on land fallowed one year. Trash left on field and stock allowed to run thereon.

Layout:

Number of plots: 32.

Size of plots: 1/10 acre each (108′ x 40.3′), composed of 24 straight rows, each one watercourse long. Rows 4.5′ x 40.3′.

Plan:

Plots	Number of Plots	Fertilization		
		N	P_2O_5	K_2O
D	11	125	0	0
E	11	125	0	60
X	10	125	70	60

Nitrogen from nitrate of soda.
P_2O_5 from reverted phosphate.
K_2O from molasses ash.

PROGRESS OF EXPERIMENT.

April 2-10, 1919—Experiment laid out.
July 9, 1919—Experiment staked.
August 5, 1919—First fertilization.
March 4, 1920—Second fertilization with nitrogen.
April 1-22, 1921—Harvested by J. H. Midkiff.

[R. S. T.]

The Value of Boiler Inspections.*

Not long ago one of our inspectors made a visit to a plant for an internal inspection of a horizontal return tubular boiler, and while in the furnace he noticed a brownish stain on the shell, well up on the side where the brick wall of the furnace and the shell join. To his trained eye this indicated a leak and he thereupon questioned the chief engineer as to whether any leakage had been noticed. The reply was in the negative, but our inspector nevertheless was not satisfied. Climbing on top of the boiler he proceeded to learn, if possible, the source of the leak that had caused that stain on the boiler shell. The engineer called his attention to a water pipe running across and somewhat above the boiler, mentioning that considerable condensation collected on this pipe and that possibly there was some water reaching the boiler from this source. This did not seem an altogether satisfactory explanation, however, so the inspector ordered some of the asbestos covering of the boiler removed at a point where he believed a leak might be. The boiler was then filled with water under pressure, and it was probably somewhat of a surprise to all present but the inspector to see water spraying out through a crack in the boiler shell as shown in the photograph herewith. The leakage was through a lap seam crack and it is practically certain that this boiler would have caused a disastrous explosion if it had remained in service. The watchful eye of the inspector, however, prevented further use of the boiler and thereby safeguarded life and property.

The case just cited brings to our mind a somewhat similar one, in which the owner had repairs made and only by good fortune was a serious accident averted. The engineer of the plant, a laundry, noticed some steam issuing through the covering of the boiler and upon investigation found that the steam came from a crack in the shell of the boiler. The crack was of the lap seam type, but the owner did not know its dangerous character and neither did the self-styled "boilermaker" he called in for advice. This "expert" said, "That's all right. Go ahead and use her till the end of the week and then shut her down. I'll be over Sunday and weld her up." He apparently did not know that autogenous welding in a case of this kind is a most dangerous practice, or else he had no regard for the safety of the fifty girls at work directly above the boiler.

One of our inspectors heard of the case and made a visit to the place. As

* From "The Locomotive."

Water issuing from a lap-seam crack.

soon as he saw the nature of the leak he advised an immediate shutdown of the boiler and also told the owner that the contemplated repairs would not make the boiler any less dangerous to operate.

A few days later a hydrostatic test was applied to the boiler and the results were practically identical with the first case mentioned. The demonstration and the inspector's explanation of the serious nature of the defect were sufficient for the owner, and not only the leaking boiler but also its mate, both of them of the same age, were removed and new ones installed. Had this precaution not been taken there might easily have been a repetition of the accident which accurred at the American Palace Laundry, Buffalo, N. Y., on November 3d, 1906. In this disaster the boiler, which was of the long seam type, failed as the result of a lap seam crack and four persons were killed. The property loss amounted to $12,000.

[W. E. S.]

The Problem of Rat Control.

In connection with requests from certain plantations to take up rat control work, we addressed the Bureau of Biological Survey, U. S. Department of Agriculture, asking for information and cooperation.

We are in receipt of a reply from E. W. Nelson, chief of the bureau, which reads:

"We have your letter of September 3rd requesting information on methods of controlling rats. We are sorry not to be in a position to assign one of our field experts to assist you in getting this important work under way, but we will gladly be of any possible service from here. We enclose a number of bulletins and circulars dealing with the control of rats that sum up fairly well our present knowledge on the subject. In rats you have perhaps the most difficult of all rodents to control.

"We have found the use of barium carbonate as described in circular Bi-414 to be the most efficient means of destroying rats, but success with this attends only painstaking use of varied and appetizing baits, following closely the directions in the circular. Caution of the danger attending the use of poisons generally should be emphasized. Poisoning has the disadvantage in that around dwellings and buildings an occasional rat may die in the walls, creating an offensive odor. In cases where the individual does not care to chance this, it is necessary to resort to trapping. The common, small, snap rat trap is to be recommended for this purpose. Clean premises and rat-proofing of buildings is to be recommended at all times. Starving out and building out the rat is the safest policy and the only permanent means of rat riddance.

"For poisoning in the big plantation fields, the use of squads of men covering the ground systematically with carefully prepared and varied baits is to be recommended. Barium carbonate can be secured in quantity at a very low figure and should be used freely, always keeping near the proportion of one part of barium to four or five parts of bait.

"We trust that this information will be of some benefit to you and that you will let us hear from you further regarding the progress of this undertaking."

The following matter is taken from the inclosures sent with Mr. Nelson's letter:

RATS AND MICE AS PESTS.

In the United States, rats and mice each year destroy crops and other property valued at over $200,000,000. This destruction is equivalent to the gross earnings of an army of over 200,000 men.

The common brown rat breeds 6 to 10 times a year and produces an average of 10 young at a litter. Young females breed when only three or four months old. At this rate a pair of rats, breeding uninterruptedly and without deaths, would at the end of three years (18 generations) be increased to 359,709,482 individuals.

Rat-Proofing.

Rat-proof construction is the ultimate solution of the rat and mouse problem, as the effects of all other devices are temporary. The best way to keep rats from buildings, whether in city or in country, is to use cement in construction. The processes of mixing and laying this material require little skill or special

knowledge, and workmen of ordinary intelligence can successfully follow the plain directions contained in handbooks of cement construction.

Cellar walls of dwellings should have concrete footings, and the walls themselves should be laid in cement mortar. The cellar floor should be of medium rather than lean concrete. Even old cellars may be made rat-proof at comparatively small expense. Rat holes may be permanently closed with a mixture of cement, sand, and broken glass, or of sharp bits of crockery or stone.

On a foundation like the one described above, the walls of a wooden dwelling also may be made rat-proof. The space between the sheathing and lath, to the height of about a foot, should be filled with concrete. Rats can not then gain access to the walls, and can enter the dwelling only through doors or windows. Screening all basement and cellar windows with strong wire netting, and covering all drain pipes, are most necessary precautions.

Farm buildings should be made rat-proof by a liberal use of cement in foundations and floors. Old corn cribs should have an inner or outer cover of galvanized wire netting of half-inch mesh and heavy enough to resist the teeth of rats. As rats can climb the netting, the entire structure must be screened.

All food supplies, garbage, and waste should be kept in rat-proof receptacles, and waste matter should be cared for in such fashion that it can not be eaten by rats.

Trapping.

Trapping, if persistently followed, is one of the most effective ways of destroying rats and mice.

House mice are less suspicious than rats and are much more easily trapped. Small guillotine traps baited with oatmeal will soon rid an ordinary dwelling of the smaller pests.

In trapping, several kinds of bait should be used, such as sausage, fried bacon, oatmeal, fish, fresh liver, nuts, apples, corn, sunflower seed, or toasted cheese. The bait should not be allowed to become stale, and the traps should be inspected daily.

Cage traps may be baited and left open for several nights until the rats are accustomed to enter to obtain food. They should then be closed and freshly baited, when a large catch may be expected, especially of young rats. It is better to cover the trap than to leave it exposed. A short board should be laid on the trap and an old cloth or bag or a bunch of hay or straw should be thrown carelessly over the top. Often the trap may be placed with the entrance opposite a rat hole and fitted so closely that rats can not pass through without entering the trap. If a single rat is caught it may be left in the trap as a decoy to others.

The ordinary steel trap (No. 0 or 1) may sometimes be satisfactorily employed to capture a rat. The animal is usually caught by the foot, and its squealing has a tendency to frighten other rats. The trap may be set in a shallow pan or box and covered with bran or oats, care being taken to have the space under the trigger pan free of grain. This may be done by placing a very little cotton under the trigger and setting as lightly as possible. In a narrow run or at the mouth of a burrow, a steel trap unbaited and covered with very light cloth or tissue paper is often effective.

Using Natural Enemies.

Small Irish, Scotch, and fox terriers, when properly trained, may be relied on to keep the farm premises reasonably free of rats.

The average house cat is too well fed and consequently too lazy to undertake the capture of an animal as formidable as the brown rat. Cats that are fearless of rats, however, and have learned to hunt and destroy them, are often

very useful about stables and warehouses. They should be lightly fed, chiefly on milk.

Tame ferrets are inveterate foes of rats, and can follow the rodents into their retreats. Under favorable circumstances they are useful aids to the rat catcher, but their value is greatly over-estimated. For effective work they require experienced handling and the additional services of a dog or two. Dogs and ferrets must be thoroughly accustomed to each other, and the former must be quiet and steady instead of noisy and excitable. The ferret is used only to bolt the rats, which are killed by the dogs. If unmuzzled ferrets are sent into rat retreats, they are apt to make a kill and then lie up after sucking the blood of their victim. Sometimes they remain for hours in the burrows or escape by other exits and are lost. There is danger that these lost ferrets may adapt themselves to wild conditions and become a pest by preying upon poultry and birds.

Among the natural enemies of rats and mice are the larger hawks and owls, skunks, foxes, coyotes, weasels, minks, dogs, cats, and ferrets. Probably the greatest factor in the increase of rats, mice, and other destructive rodents in the United States has been the persistent killing off of the birds and mammals that prey on them. Animals that on the whole are decidedly beneficial, since they subsist upon harmful insects and rodents, are habitually destroyed by some farmers and sportsmen because they occasionally kill a chicken or a game bird, when, as a matter of fact, rats actually destroy more poultry and game, both eggs and young chickens, than all the birds and wild animals combined.

Organized Campaigns.

The necessity of cooperation and organization in the work of rat destruction is of the utmost importance. To destroy all the animals on the premises of a single farmer in a community has little permanent value, since they are soon replaced from nearby farms. If, however, the farmers of an entire township or country unite in efforts to get rid of rats, much more lasting results may be attained. If continued from year to year, such organized efforts are very effective.

Summarizing, the war against rats should be continued by—

(1) Rat-proof construction;
(2) Shielding food supplies;
(3) Protecting natural enemies;
(4) Exhaustive trapping, poisoning, and organized hunts.
(5) Community action.

DIRECTIONS FOR POISONING RATS WITH BARIUM CARBONATE.

General Rules.

Remove so far as practicable all accessible food before setting out poison for rats.

All baits must be fresh and of good quality.

Premises should be inspected each day to remove dead rats and to pick up and destroy uneaten baits.

Trials should be made to find what baits rats will eat at any particular time or place, as they vary their diet according to the season and local conditions. One bait from each of the three following classes should be treated with barium carbonate, thus making up three separate kinds of poisoned bait.

Kinds of Bait.

Meats.—Hamburg steak, sausage, fish, fish offal, crab meat, fresh liver, broken fresh eggs, bacon.

Vegetables and fruits.—Thin slices of cantaloupe, apple, tomato, or cucumber; green corn, cut from cob; mashed banana, boiled carrot, or baked sweet potato.

Other foods.—Toasted bread, cheese, rolled oats, cereals, peanut butter.

Treatment with Barium Carbonate.

Thoroughly mix barium carbonate through the soft baits with the hands or with a spoon in the proportion of one part barium carbonate to four parts of bait. Add water when necessary to make the baits moist.

Sift barum carbonate over the sliced baits and rub it into them with fingers or knife.

Distribution of Prepared Baits.

A teaspoonful, or a small portion, of each of the three separate baits should be set in runways or other places frequented by rats. Set groups of these three baits on strips of paper or board at intervals of 10 to 20 feet.

For any uneaten bait, substitute on the following night another from its class. If none is eaten, substitute an entirely new series. Continue to set poison at frequent intervals until all rats disappear.

To set poison in poultry inclosures.—Over the poisoned bait place a small box with holes of 2-inch diameter at each end, and over the small box place a large box with holes of 2-inch diameter at each side. The bait should be very wet or of such consistency that the rats can not drag it from under the boxes.

Caution.—Keep barium carbonate out of reach of children and irresponsible persons and from domestic animals and fowls.

Antidote for barium carbonate.—Give an emetic of salt, mustard, and warm water followed by Epsom salts or Glauber salts. Call a physician or veterinarian, as the case may require.

DIRECTIONS FOR POISONING RATS WITH STRYCHNINE.

Follow the same general rules and use the same kinds of baits as for poisoning with barium carbonate.

Strychnine is too rapid in action to make its use for rats desirable in houses, but elsewhere it may be used effectively. Strychnine sulphate is the best form to use. The dry crystals may be inserted in small pieces of meat, cheese, fruit, or vegetable baits, and these placed in rat runs or burrows; or oatmeal or other cereals may be moistened with strychnine syrup and small quantities laid in the same way.

Strychnine syrup is prepared as follows: Dissolve ½ ounce of strychnine sulphate in 1 pint of boiling water; add 1 pint of thick sugar syrup and stir thoroughly. A small quantity may be prepared with a proportional quantity of water and syrup. In preparing the baits it is necessary to moisten all the oatmeal with the syrup. Wheat and corn are excellent alternative baits. The grain should be soaked over night in the strychnine.

Antidote for strychnine.—Use an emetic of mustard, followed by large draughts of warm water, and give powdered charcoal. Keep patient in a quiet place, avoiding noise, quick movements, or anything which may startle or disturb. To relieve spasms let patient inhale pure chloroform or give chloral hydrate (25 grains).

DIRECTIONS FOR TRAPPING RATS WITH GUILLOTINE AND CAGE TRAPS.

Rats are often very cunning. It is often difficult to clear them from premises by trapping; if food is abundant, it is nearly impossible. Under favorable conditions, where rat-proofing has made access difficult and the food supply has

been cut off, trapping, if persistently followed, is one of the most effective means of rat control. A common mistake in trapping for rats is to use only one or two traps where dozens are required. For large establishments, such as warehouses, office buildings, and apartment houses, from 20 to several hundred traps may be required; at least 100 traps are required to properly control rats on a medium-sized farm.

Guillotine Trap and Baits.

For general use the improved modern traps with a wire fall, released by a baited trigger and driven by a coiled spring, have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called "guillotine" traps, are of many designs, but the more simply constructed are preferable, and usually more effective than cage traps. Probably those made entirely of metal are best, as they are more durable.*

Remembering that the rat is practically omnivorous, feeding upon all kinds of animal and vegetable matter, baits should be chosen accordingly. Perhaps the most consistent results will be obtained by using baits made from bacon, beef, fish, fresh liver, nut meats, and cheese. Baits should be large, full size of the trigger and secured to it by tying with string or fine wire. The guillotine trap with extended trigger may also be used without bait, upon ledges, narrow rat runs, along the walls, or at the opening of rat burrows. The trigger on all traps should be adjusted to act instantly.

Cage Traps and Baits.

When rats are abundant, large French wire cages may be used to advantage. They should be made of stiff wire, well reinforced. Many of those sold are useless because a full-grown rat can bend the wires and escape.

The baits recommended for guillotine traps may be used in the cage trap. A combination of baits cut in large size can be fastened on a wire hook suspended from the top of the cage on the inside. Pre-baiting is often necessary, allowing the traps to remain open for one or two nights before closing. Twenty-five or more rats have been secured during the night from this procedure. Better results will be secured if traps are covered than if left exposed; an old cloth or bag thrown over the top will be sufficient covering.

Fence and Battue.

This method is applicable at the time of removal of piles of grain, hay, straw, rubbish, and brush. A wire netting or a wooden pen may be used for the inclosure, which should be set up around the pile. The pile of material is then thrown out, allowing dogs and men to get at the rats. Hundreds of rats may be destroyed in this manner in a few hours.

COMMUNITY ORGANIZATION FOR ERADICATING RATS.

Control of rodents is best effected through community cooperation, and organization should be under the direction of a committee representing local civic organizations, such as the Chamber of Commerce, Farm Bureau, Board of Trade, Board of Education, or departmental heads. Communities, both rural and urban, should be divided into precincts, school districts, city block, or group of city blocks, each division to be under the direction of a captain and such assist-

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*** Manufacturers of rat traps: J. R. Schuyler & Co., Bloomsburg, Pa.; Animal Trap Co., Lititz, Pa.**

ants as are necessary to conduct a complete organization. The aim should be to develop a permanent organization, to be supported by cooperating State and Federal departments. Such campaigns should be outlined to cover a definite period of time and naturally lead up to important repressive measures and more concrete methods of permanent rat control. Campaigns of short duration should not be undertaken.

Funds.

Money for such campaigns should be provided by public subscription, and all should be encouraged to contribute. Such funds should be paid out as prizes rather than bounties, as this will create a friendly rivalry, stimulating contestants to the utmost without quickly exhausting the funds, as in the case of paid bounties. Prizes should be offered for all phases of rat control, such as the greatest number of rats taken, the cleanest district, the greatest number of garbage cans installed, essays by school children on life history, habits, and control of the rat, and for simple rat-proofing work. Funds can be used for the wholesale purchase of traps and poison if desired.

Important Measures to Guide Campaigns.

Important points to strive for in campaigns are cleanliness in markets, stores, warehouses, slaughter houses, alleys, stables, vacant lots, and dwellings, storage in rat-proof containers of waste, garbage, and manure, and prompt removal of the same daily; destruction of old straw or other trash piles, and the wrecking of old sheds, buildings, and walks; piling of lumber, wood, etc., in close stacks at a distance of 18 inches above ground.

Rat-Proofing.

Provisions, grain, and food stuffs should be protected in rat-proof buildings and containers. In rat-proofing granaries, hog pens, poultry houses, dwellings, and stables, quarter-inch steel or wire mesh, sheet metal, or concrete may be used, close attention being paid to ventilation-traps, eaves, and doors, and the lower floors of buildings.

Protection of the Natural Enemies of Rats.

Hawks, owls, and small predatory animals are natural enemies of rats.

Traps.—Where traps are depended upon, a large number should be used, frequently 100 or more to the farm or warehouse. The guillotine type of trap is recommended. Traps should be baited with fresh meat, fish, bacon, sausage, cheese, vegetables, or fruit. Baits should be large and secured by tying to the trigger plate. Traps should be looked at at least three times each day.

The large French cage trap is very good for use in stables, warehouses, and sewers. Pre-baiting should be followed for several nights before closing the trap, using baits of any food material in large quantity suspended by wire from the top of the trap on the inside. Traps should be covered with an old cloth or bag.

Poisons.—Two kinds of poison are used against rats—barium carbonate, in occupied houses or buildings; strychnine (sulphate), for outside work. In the use of poisons care must be exercised to protect children, domestic animals, and fowls. All rats collected for counting should be cremated or buried two feet deep and not thrown into the streets or highways.

[H. P. A.]

SUGAR PRICES FOR THE MONTH

Ended September 15, 1921.

		96° Centrifugals Per Lb.	96° Centrifugals Per Ton.	Beets Per. Lb.	Beets Per Ton.
	(Aug. 16, 1921)......	4.8125c	$ 96.25	No quotation.	
[1]	" 17	4.61	92.20		
	" 18	4.50	90.00		
[2]	" 22	4.61	92.20		
	" 25	4.50	90.00		
[3]	" 26	4.625	92.50		
	" 29	4.61	92.20		
[4]	Sept. 2	4.80	96.00		
	" 7	4.5417	90.834		
	" 8	4.375	87.50		
	" 9	4.75	95.00		
	" 13	4.25	85.00		
	" 15	4.00	80.00		

[1] Sale St. Croix.

[2] This sale covers 2200 tons uncontrolled Cubas.

[3] One export sale San Domingos 4.75. Another Porto Ricos. Regular basis domestic sugars 4.50. Cubans holding 4.86.

[4] San Domingos, 30,000 bags.

THE HAWAIIAN PLANTERS' RECORD

Volume XXV. NOVEMBER, 1921 Number 5

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

The Proposed Program of Bud Selection Work.

We now have at hand information and evidence that convince us that the yields of the cane fields in these Islands can be increased by selecting and propagating the superior strains of our leading sugar cane varieties.

The benefit which is to come from this can be greatly expedited if the industry will set a goal for itself and make plans to reach that goal by a given time.

We believe that it is entirely practicable for the plantations of this Association to decide now that *all cane planted in 1924 will be from nurseries of selected cane.*

Within the next twelve months our representatives can work with each plantation in selecting and planting out a mother field of from two to ten acres, say five acres on an average to a plantation. Five acres on forty plantations make two hundred acres of nursery land. A year later this cane can be handled in two ways:

1. Make a re-selection to find the very best strains.
2. Spread any and all of it that is superior to the general run of the plantation as rapidly as possible. Perhaps half of the mother field can be discarded to advantage. The balance planted with ample spacing can serve to extend the two hundred acres to four thousand in 1923. This will provide all the seed cane the industry will be prepared to plant in 1924.

While this will mean much to the plantations, it does not indicate the final aim of bud selection work. It serves to help the plantations while the project is continued in the search and propagation of those strains of cane of outstanding superiority. Once we have large fields planted in the way we have described, the work of finding the very best strains will be greatly facilitated.

All plantations desiring to cooperate with the Experiment Station along these lines should notify us far enough in advance to be included in the program of work that is being arranged.

The Fern Weevil Parasite.

Its Life History and Introduction to Hawaii.

By C. E. PEMBERTON.

Since the first appearance of the destructive Australian fern weevil *Syagrius fulvitarsis* Pasc. in the Hawaiian Islands, and its subsequent spread during recent years into the beautiful fern forests near Kilauea on the Island of Hawaii, much discussion has occurred respecting its possible origin. D. T. Fullaway, in a paper on the life-history of the weevil,[1] concludes that it is of Australian origin, since it has been recorded only from that country, together with another related species, *Neosyagrius cordipennis* Lea, taken by W. W. Froggatt in the Botanic Gardens in Sydney. Another species, *Syagrius intrudens* Waterhouse, was collected in the Botanic Gardens of Dublin, Ireland, in 1902. The following facts would rather prove his contention to be correct.

Material of *fulvitarsis* was originally collected by French of the Melbourne Botanic Gardens, in 1857, and given the label Wien Wien, Richmond River, New South Wales. No additional data were included. W. W. Froggatt later found it abundantly infesting ferns in greenhouses and adjacent fern plots in the Botanic Gardens in Sydney.

With the object of locating the weevil, if possible, in its native habitat, in order to investigate its natural enemies, if present, a visit was made to the Richmond River in northern New South Wales in April, 1921. After considerable search, the weevil was finally located on ferns in a heavily forested country near the town of Dunoon, in the district of Whian Whian. This was no doubt the territory called Wien Wien by French in 1857. The weevil was also found at Lismore, in an uncut forest reserve, some 15 miles from Dunoon, then at Nimbin, a small town near the headwaters of the Richmond River; and in June, at the suggestion of Mr. Froggatt, a search was made in the virgin forests near Bulli, New South Wales, about 500 miles south of the Richmond River, and it was found there also.

At Nimbin, conditions for the search for parasites were most suitable, the town being close to an extensive mountainous district densely covered with great virgin forests. Here the parasite *Ischiogonus syagrii* was finally found. It was bred from larvae of the weevil taken in the native forests all about the town, and two months later the same wasp was found highly parasitizing the weevil at Bulli. The beetle, its larvae, and the parasite were found in forests untouched by man and remote from farmhouses, roads, or logging trails. This was fair proof of the nativity of *Syagrius*. Additional and yet more conclusive evidence, however. was obtained upon finding another weevil on ferns here, which, according to A. M. Lea of the Adelaide Museum, is a distinct and hitherto undescribed species of *Syagrius*. Nowhere were either of the weevils found abundant enough to interfere with the growth of even the tenderest of ferns. A large number of

[1] The fern weevil *Syagrius fulvitarsis* Pasc. D. T. Fullaway. Hawaiian Forester and Agriculturist, Vol. XVIII, 5, pp. 101–114. 1 plate. May, 1921.

different species of ferns flourish in New South Wales and the weevil was ultimately taken from every species examined, including tree ferns and a common, coarse bracken. It was most readily found on the softer species. Yet in all the forest regions visited the beetle was comparatively rare. On some days, during the search for parasites, not more than a half-dozen weevils or larvae were found, and occasionally a full day's work brought nothing. This indicates the extent to which the insect is under natural control.

In spite of this scarcity of the weevil, the parasite *Ischiogonus* was practically always with it and maintainlng a parasitism estimated at close to sixty per cent.

In addition to the parasite *Ischiogonus syagrii,* a few individuals of another parasite, also found on the weevil-larvae, were bred. P. H. Timberlake has placed these in the genus *Eupelmus,* and concludes that it is probably a primary parasite also. The habits of this species were not investigated.

As noted above, *Ischiogonus* is a larval parasite. In order to ship it in quantity to Honolulu, larvae of the weevil, bearing eggs or larvae of the parasite thereon, were collected as rapidly as they could be found and placed, usually separately, in small glass vials plugged with a cotton stopper. The *Ischiogonus* larvae spun perfect silken cocoons in the vials after consuming the weevil-larvae. These vials were then taken to Sydney, some four hundred miles south, on two separate occasions. The first lot was placed on the steamship *Makura* on May 4th, 1921, and the second lot on the *Ventura* on May 31st. In both cases portions of each lot were placed in the ship's fruit or vegetable compartment, wherein a temperature of about 45° F. is constantly maintained. The other portions were kept at normal temperatures. In each case both portions of both shipments reached Honolulu in a satisfactory condition, and a total of 319 parasites ultimately hatched out. with both sexes well represented. Messrs. Muir and Fullaway liberated the first lot among weevil-infested ferns on Mt. Tantalus, back of Honolulu. The second lot was variously distributed on the Islands of Oahu and Hawaii by Mr. Fullaway. A few months after the first lot was set free he found parasitized weevil-larvae in the vicinity of the point of liberation, thus showing that the parasite will very probably establish itself in Hawaii.

The following is presented to indicate briefly the development and habits of this parasite:

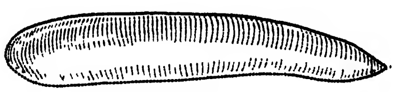


Fig. 1—Egg of *Ichiogonus syagrii.*

The Egg—The egg, when first laid, is .7 mm. long, less than a fifth as wide, smoothly surfaced, pearly white, rounded at one end, bluntly pointed at the other and slightly curved, giving one side a faintly concave outline, as shown in Fig. 1. Upon maturing it becomes pale-yellow and is a little broader than when first deposited. It is placed loosely upon the surface of the host-larva and may be found at any portion of the body, but most often on the cephalic half, as shown in Fig. 2, near the head of the *Syagris* larva. Eggs have been occasionally found within the fern stem lying free from the larva, but very close to it. These hatch normally and the parasitic larvae reach the host without apparent difficulty. As the eggs are not cemented on, nor inserted into the tissues of the *Syagrius* larva, it is quite possible that they occasionally become brushed off of its body by its sub-

sequent slight movements in the fern stem following parasitization. From one to four eggs are generally placed on a single larva. These all hatch normally, and if the host is a fairly large individual, these will all ultimately mature to average sized parasites. Exceptional cases have been observed in which as many as six eggs occurred on a single larva. These are deposited singly by one or more females.

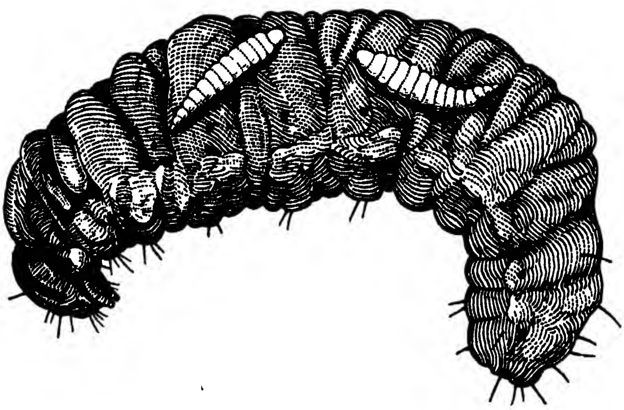


Fig. 2—Mature *Syagrius* larva, showing two *Ischigonus* larvae feeding upon it and one *Ischiogonus* egg in natural position.

The duration of the egg stage was determined only during the early winter months in New South Wales. It varied from six to seven days, the temperature ranging between 48° and 65° F. In the forest summer temperatures in Hawaii this period will no doubt be much shorter.

The Larva—Upon hatching, the larva is a pale white, almost transparent, less than 1 mm. in length, showing fourteen distinct body-segments, including the head, and bearing a well-defined, open, tracheal system. It possesses a pair of short, sharply-curved acutely-pointed and exceedingly minute mandibles, indicating a faint brownish chitinization near the tips. The larva is capable of considerable movement, though it moves very slowly. It lies during the complete development on the surface of the weevil-larva, imperceptibly puncturing the skin and sucking the body juices. The growth is very rapid and within a few days the larva has doubled in size. The exact number of molts was not determined. There would appear to be at least three. As growth continues, a minute pair of antennal processes become visible near the front of the head, as shown in Fig. 3a. The mandibles, though changing little in size or shape, become more heavily chitinized, resembling those shown in Fig. 3b, greatly enlarged. The antennal processes are easily visible in the mature larva, their function being unknown. The larvae usually lie almost motionless upon the surface of the host. The body may occasionally bend slightly to right or left or move forward faintly. A *Syagrius* larva, if removed from a fern-stem following a recent parasitic attack, will frequently resemble that shown in Fig. 2. One or more glistening, pale-white larvae may be seen feeding upon its body, and sometimes an unhatched egg is present with them.

At maturity the *Ischiogonus* larva is much the same in general appearance as when first hatched. It has, however, increased greatly in size and can move about much more actively. Still the movement is sluggish. It usually varies from 3 to 5.5 mm. in length, depending upon the amount of food available for it. If one has developed singly upon a large *Syagrius* larva, it will be correspondingly large. If, however, there have been four or five developing together on the same host, the quantity of food will not have been so great and all may reach maturity at somewhat less than 3 mm. in length. The full-grown larva is covered

with fine, short, sharp spines, broad at the base, translucent, and occurring only on the first to the twelfth body-segments back of the head, they being especially numerous on the first segment. The dorsum of the fifth to the ninth segments, inclusive, is somewhat protuberent, as shown in Fig. 4. These characters are not visible in the immature larval stages.

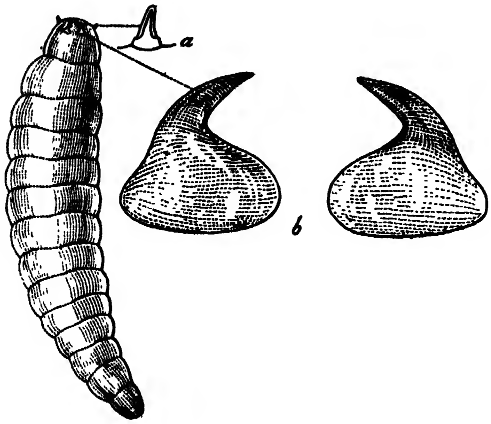


Fig. 3—Well-grown *Ischiogonus* larva, ventral view, showing (a) antennal process greatly enlarged, and (b) mandibles, also greatly enlarged.

With the growth of an *Ichiogonus* larva on the surface of the *Syagrius* larva, the latter shrinks, slightly at first, but more rapidly as the fluids are extracted and the parasite increases in size. It finally collapses entirely and assumes an appearance somewhat like that shown in Fig. 4. Hardly anything remains but the wrinkled integument and the hard, brownish head, and in the midst of these remains lies the glistening, fully-engorged *Ischiogonus* larva, ready to creep away a short distance in the hollow stem and spin its cocoon.

During the winter months in New South Wales, the active larval stage was found to occupy from nine to eleven days, this occurring at temperatures ranging between 48° and 70° F. This is a very rapid development, considering the temperature.

The Cocoon and Pupa—Upon reaching full growth, the *Ischigonus* larva, as above stated, usually moves away from the remains of the dead *Syagrius* larva, which it has fed upon and destroyed. It often crawls from one to one and one-half inches along the channel in the fern stem originally made by the weevil-larva. Here is slowly spins around its body a white, silken cocoon. This requires, in the winter temperatures of New South Wales, from 24 to 48 hours. The cocoon usually varies from 4.7 to 6.5 mm. in length, depending upon the size of the larva spinning it, and from 1.2 to 1.8 mm. in diameter. It is cylindrical, and bluntly closed at each end, as shown in Fig. 5. When several larvae mature on the same host their cocoons may frequently be found in an almost continuous chain in the fern - steam, but sometimes they may overlap or even lie side by side. At the temperatures above referred to, a considerable period

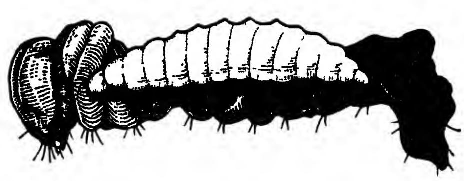


Fig. 4—Partly consumed *Syagrius* larva, upon which is a mature *Ischiogonus* larva.

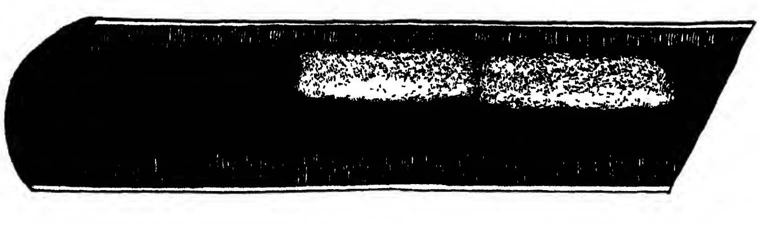


Fig. 5—Section lengthwise through fern stem, showing two *Ischiogonus* cocoons in natural position.

elapses between the apparent completion of the cocoon and pupation. All larvae under observation finally pupated from seven to eight days after the cocoon was constructed. The larvae could be daily observed within the delicate cocoons by examination under direct sunlight. The time required for spinning the cocoon and the prepupal period passed therein was the same for large, well-nourished larvae as for the very small, poorly-fed individuals.

Pupation was readily observed without cutting open the cocoons. At the same temperatures, the pupal stage was found to cover from eighteen to nineteen days. Under Honolulu temperatures it will be much shorter.

The Adult—The adult wasp emerges by gnawing open one end of the cocoon. If the end of another cocoon lies directly in front and against it and still contains a pupa, the adult bites its way through the side of its own cocoon, near the end. If the cocoon in front of it is empty, the adult from it having already passed out, the wasp cuts through the end of its own cocoon, through the back end of the one in front of it, and crawls through the latter to emerge. Sometimes from three to five such cocoons will be in a row and the wasp from each will ultimately pass out through the outer end of the last cocoon. Once into the hollowed fern-channel the parasite cuts a clean, somewhat circular hole directly through the wall of the fern-stem and escapes.

Mating may occur immediately after emergence, and oviposition has been noted four days later, in cool temperatures. Mature eggs were not found in quantity at any time within the egg-tubes of females, either freshly emerged or several weeks old. At the time of hatching not more than two mature eggs have been found in a female, and the greatest number of well-developed eggs ever dissected from any female, irrespective of age, was twelve. This indicates a rather slow rate of oviposition. The adult, however, is very hardy and long-lived. Of twelve adults kept in glass tubes and given neither food nor water, two lived for eighteen days, one for sixteen days, three for eleven days, and the remainder for from seven to nine days. When fed regularly on a solution of raw sugar and water, the adult can be kept alive for long periods, the males succumbing first. Of eighteen females and eight males, kept in such a manner, in an ordinary test-tube, indoors, at New South Wales winter temperatures, seven males lived from forty-eight to seventy-seven days, one male lived eighty-two days, and all of the females,

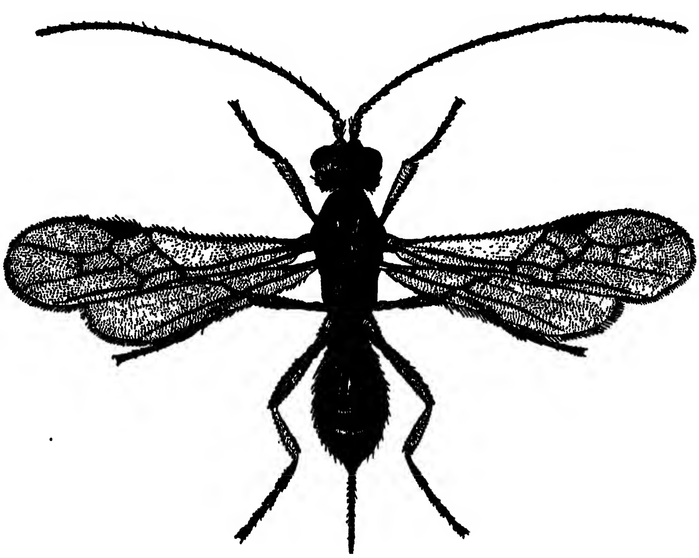


Fig. 6—Adult female *Ichiogonus syagrii.*

but one, are at the present writing still actively alive and ninety-one days old. They have had no opportunity to oviposit. If such had been the case is is hardly probable that they would all still be living.

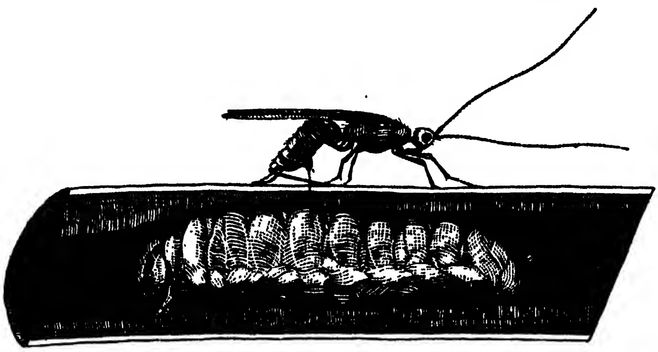


Fig. 7—Section lengthwise through fern stem to show *Ischiogonus* female ovipositing on *Syagrius* larva.

The female has no apparent difficulty in locating weevil-infested fern-stems. In moving about on a fern, the female will pause upon a spot beneath which lies a weevil larva, and after some hesitation and curious maneuvering, occupying sometimes a minute or more, will bring the tip of the ovipositor against the stem and gradually force the sharp ovipositor-blades through the tissue and into the larva, the sheadth not penetrating the fern but extending forward beneath her body and acting somewhat as a guide for the flexible blades. This process may occupy fifteen minutes or more, depending upon the toughness of the stem. Individuals have been timed for twenty minutes before the piercing of the fern and the placing of a single egg had been completed. The stinging of the larva evidently partially paralyzes it, and this effect is permanent, for it remains almost totally immobile thereafter. The general position of the female, when the ovipositor is fully inserted into the stem and against the larva, is shown in Fig. 7. Before removing the ovipositor, a single egg is deposited upon the surface of the larva. Sometimes larvae are stung but no egg is deposited. They have frequently been found in a semi-paralyzed condition without eggs or parasitic larvae thereon or near them in the stem. Usually well-grown larvae only are parasitized, but occasionally half-grown individuals have been found, bearing from one to four *Ischiogonus* eggs or larvae. In such cases the parasites may mature, but are very diminutive, owing to the absence of sufficient food. Such adults have been reared which were only 2.3 mm. in length. With abundance of food, a larva may develop to an adult sometimes 5.5 mm. in length. Females will oviposit on the same larva more than once, and no doubt different females will attack the same larva successively. This accounts for the presence of *Syagrius* larvae bearing *Ischiogonus* eggs and immature larvae at the same time, showing that eggs had been deposited at different intervals.

The complete life-cycle of *Ischiogonus,* under the fairly cold winter conditions of New South Wales, was found to require about forty-four days. This cycle in Hawaii during winter will probably be even less, and much shorter in summer. Mr. Fullaway has found that the life-cycle of the weevil requires from 105 to 135 days in Hawaii. Considering the hardiness of the parasite and its exceedingly short life-cycle, compared with that of its host, a rapid checking and early control of the pest can be reasonably expected. It is particularly promising from the fact that this parasite was found flourishing in dark, wet, rainy forests in New South Wales, quite comparable with those conditions prevailing in the Hawaiian Islands where the weevil has gained a foothold.

Some Observations on Figs in South-Central Luzon, Philippine Islands.

By Francis X. Williams.

These observations have been developed from a study of certain figs and fig insects which it seemed desirable to introduce into the Hawaiian Islands.

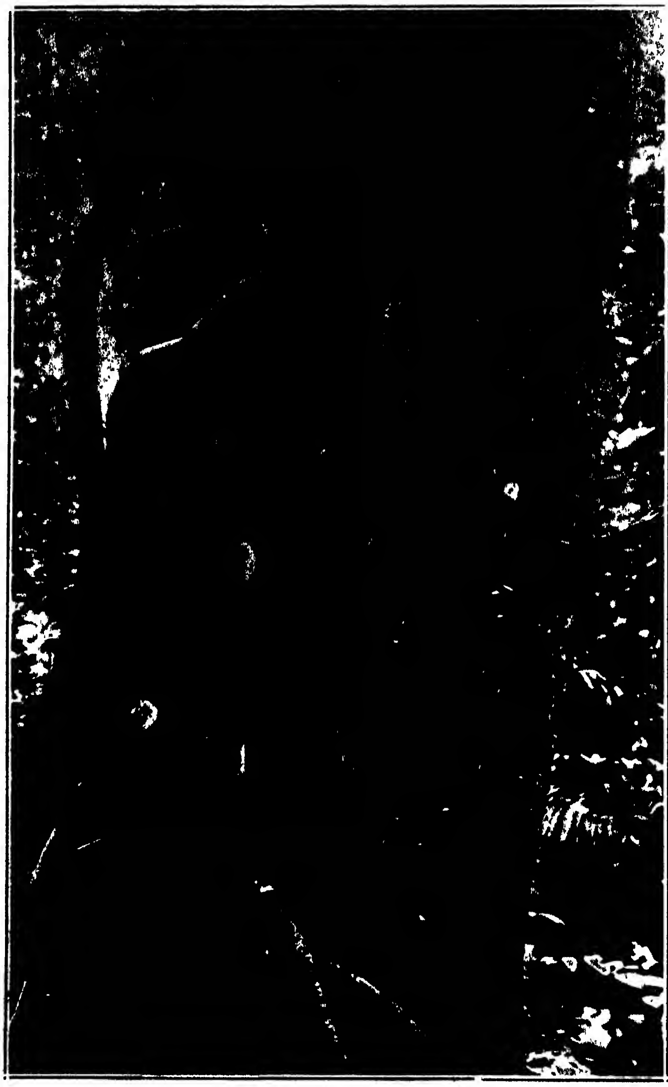


Fig. 1. *Ficus megacarpa.* Young vine at right, mature vine at left, on the tree, *Pentacme contorta.* Mount Maquiling.

They concern themselves mainly with these plants as occurring in their natural habitats and scarcely touch upon the entomological aspects of the subject.

The results are based upon eight months of field work undertaken chiefly on and about Mount Maquiling, near Los Baños, about forty miles southeast of the city of Manila. In addition, three expeditions were made to other forests;

the first to Mount Marivales, in Bataan province, across Manila Bay and nearly west of that city; the second to Mount Banahao, a large extinct volcanic cone some miles northeast of Mount Maquiling; while the third trip included a very interesting cross-country journey on foot, under the auspices of an officer of the Bureau of Forestry, across the rather low mountain range, from the eastern shore of Laguna de Bay, northeast to the Pacific Ocean. Many photographs of *Ficus* were taken and a few of these are shown here.

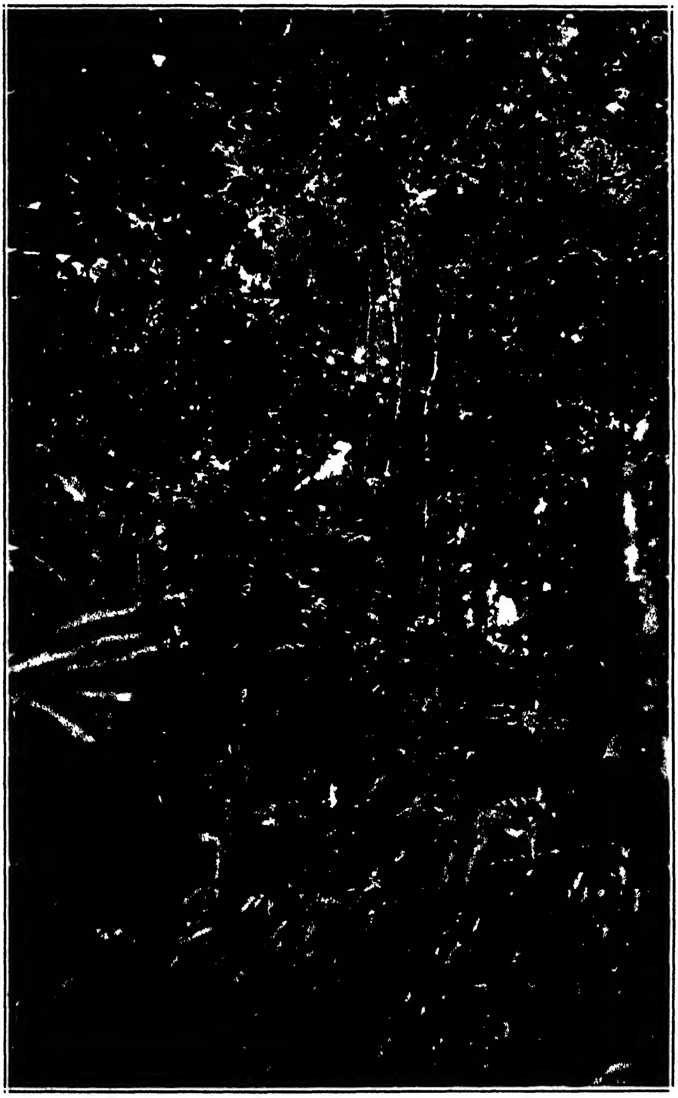


Fig. 2. *Ficus megacarpa* in fruit on the tree, *Pentacme contorta.* Mount Maquiling.

The Mount Maquiling region is especially rich in species of figs, and I have been fortunate in being stationed at the College of Agriculture, at the foot of the mountain, and where every help has been given me in my work, both by the Bureau of Forestry and the College of Agriculture here. My thanks are also due to E. D. Merrill, Director and Botanist of the Bureau of Science, in Manila,

for criticism, and particularly for the identification of most of the figs I collected.

Many hundreds of species of *Ficus* have been described, and these are distributed mainly over the tropical and subtropical parts of the globe. About two hundred are known from the Philippines and an equal number from New Guinea alone! To a certain extent, the writer has studied the comparatively inconsid-

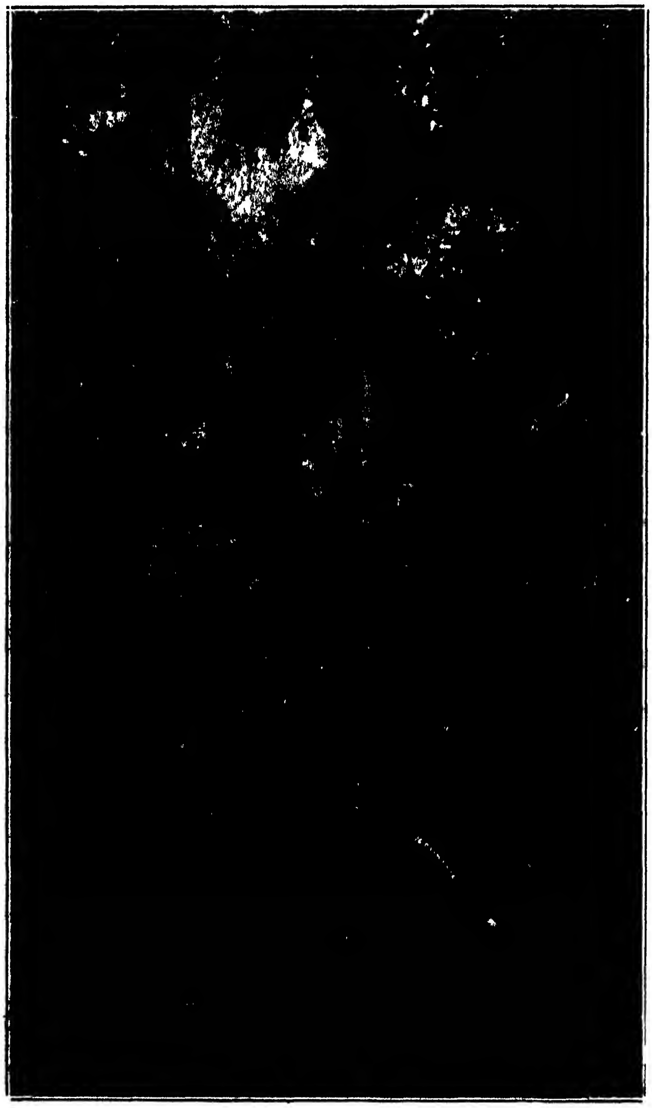


Fig. 3. An *Eugenia* sp. tree being strangled by *Ficus clementis.* The vine mainly on the left side is *Ficus megacarpa.* Mount Maquiling.

erable number of about forty-five species, but since these represent several types of plants the collection may be regarded as fairly typical. I have refrained thus far from calling figs trees, for while probably the majority may be so designated, not a few are mere shrubs, while others are vines. Furthermore, one must not get the impression that even a fair proportion of the species of wild *Ficus* bear

delicious figs; the contrary is true. Here about Los Baños I have found but three species of palatable figs, and these are distinctly inferior to the figs of commerce.

For the purposes of this very general paper, fig plants may be separated conveniently into four groups, as follows:

(1) Stout lianas, or vines, climbing high up on the trunks of trees, their foliage not being very ample. Few species.

(2) Sprawling or climbing shrubs, that grow over boulders, logs, stumps, or upon trees. Not very strongly clasping. A moderate number of species.

(3) "Baletes" or Strangling Figs, which commonly kill their tree host by very tightly enmeshing the trunk with a network of roots which finally grow together, the underground roots and the foliage also interfering; the host is ultimately smothered and disappears. Numerous species.

Fig. 4. *Ficus subulata* sprawling over a boulder. Mount Maquiling.

(4) Figs neither vine-like nor stranglers, but growing as independent trees or shrubs. One subdivision bears figs from twigs in the usual manner; the other is cauliflorous, that is, the fruit is borne on special branches or tubercles from the trunk or larger branches. Numerous species.

These four divisions are not wholly natural or scientific, inasmuch as the flowers and fruits have not been considered, and these of course form the basis of plant classification. The third division here includes baletes only and these bear figs, each and all of which, as far as observed, contain male, true female, and gall flowers, the latter being modified for the development of the *Blastophaga* or fig-pollinating wasps. Divisions one, two, and four have male and female plants; that is, the male plant bears figs containing perfect male flowers and gall flowers, while the female tree bears figs with true seed flowers and per-

haps also imperfect male flowers. Variations tend to complicate this classification.

In the first group, I have found but two species, *Ficus Bakeri* Elm. and *Ficus megacarpa* Merr. growing as stout lianas. Neither appears to be an important element in the forests. A specimen of *F. Bakeri* was noted growing upon an immense strangling fig, *Ficus clementis* Merr., at an altitude of about

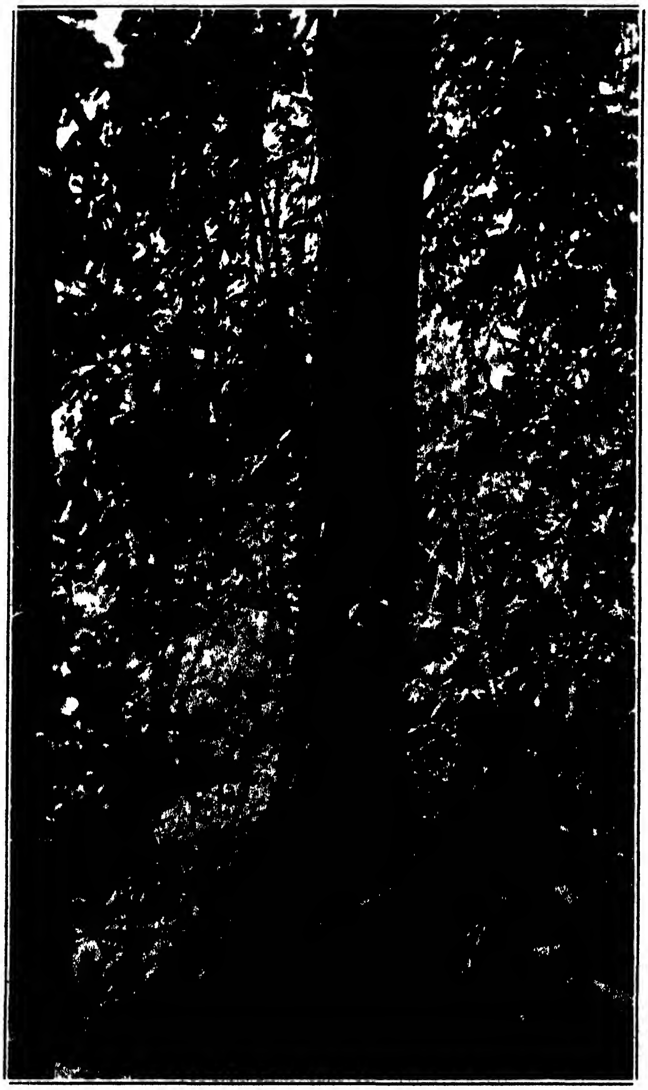


Fig. 5. *Ficus caudatifolia* embracing its host. Mount Maquiling.

1500 ft. The stout cable-like vines of *F. megacarpa,* often three or four inches thick, are fairly common on tree trunks at lower and middle elevations to two thousand feet or so in the Maquiling forest. In early life the plant is a delicate little vine (Fig. 1, right side), clinging along a tree trunk by means of rootlets. Such vines may arise also from one of the main roots below ground. The stoutest of the three vines in Fig 1 is the basal portion of a mature *F. megacarpa* growing

on the dipterocarp, *Pentacme contorta* Merr. and Rolfe, while Fig. 2 shows a more distant and extensive view of the same individual fig with several dozens of its nearly spherical fruits along the stem. In Fig. 3 is shown *Ficus clementis* enmeshing a large *Eugenia* tree, while crossing it from near the base, from right to left, and running mainly along the left side of the trunk to the crown of the tree, is a large *F. megacarpa*. Here at the base of the crown it sends out a few inconspicuous leaves.

Fig. 6. A large strangling fig with bird's-nest ferns (*Asplenium* sp.) upon it. Tayabas Province.

Ficus megacarpa is related to the climbing fig, *F. heterophylla,* introduced years ago into Hawaii. It has the largest fruit of any fig that I have seen, for these may attain a diameter of 8 cm., or about 3⅛ inches. When ripe they are of an orange or russet color. The milky juice is exceedingly viscous and makes their dissection a disagreeable matter.

Ficus, probably *lamaensis* Merr., and *Ficus*, probably *apiocarpa* Miq., I observed as rather slender vines on the trunks of trees. *F. apiocarpa*, with its tolerably large and handsome leaves, grows at a rather high altitude. Neither of these two vines was found in fruit.

The second group also contains relatively unimportant plants, three species of which are known to me. They are climbers or semi-climbers and do not attain

Fig. 7. A large strangling fig in Tayabas Province.

a large size. *Ficus subulata* Bl., Fig. 4, sprawls over boulders along streams. It has rather large shining leaves and small fruit. *Ficus philippinensis* Miq. resembles it but is more of a climber. *F. caudatifolia* is a larger plant than the above two species and has a semi-balete or strangling-fig habit, for it somewhat enmeshes the trunk of its host, but not so tightly as to injure it. (Fig. 5.) Its

striking orange-colored fruits, as much as an inch in diameter, often hang down in picturesque clusters from slender twigs.

The third group is by far the most conspicuously represented in the forest proper, but in the drier lowlands group four predominates. The "baletes" or strangling figs are very abundant on Mount Maquiling up to at least 3000 feet, and on Mount Marivales extend well into the mossy forest. They are not found to be plentiful along the trail on Mount Banahao, and only moderately so, but more as large trees (Figs. 6 and 7), in the better Tayabas forest. Along the Pacific shore of Tayabas, a little south of the town of Infanta, they were plentiful just behind the beach, where, according to the nature of their host, they existed as large, more or less erect trees, or else inclining and spreading awkwardly.

On Mount Maquiling is a great variety of strangling figs, some vine-like, others trees of fantastic shapes, others still huge, erect, and wide-spreading.

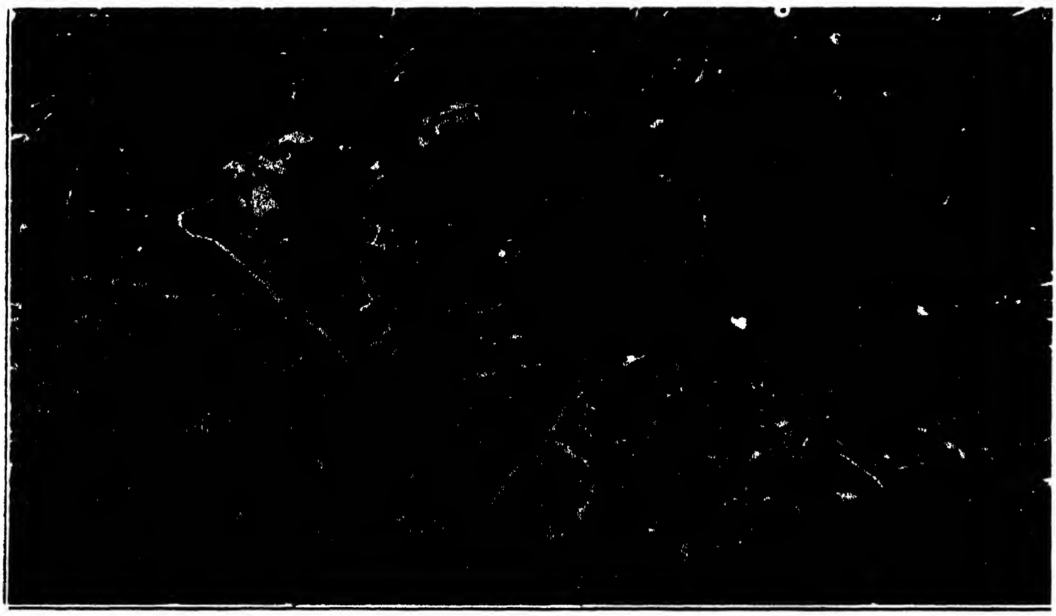


Fig. 8. Roots of *Ficus adamii* going down to water. Mount Maquiling.

These plants require considerable moisture, and in the lowlands occur mainly along watercourses or lakes. Where necessary they send down long roots to moisture. Fig. 8 shows roots of one individual of *Ficus adamii* Elm. dipping into a stream in the Maquiling forest. A large specimen of *Ficus calophylloides* Elm. sent down a stout root from the base of its trunk, for some eighty or more feet to a small stream bed.

Strangling figs are commonly known in forestry as "weed" trees. While rather a detriment than an asset in a commercial forest, these trees make a fair addition to the watershed cover. Some of the species are among the largest trees in the forests.

They are not properly parasitic, for although attaching themselves to trees, they begin life as epiphytes, i. e., "as a plant growing on another plant but not nourished by it," usually lodged well up upon their host, having started from a

seed dropped there by some bird or other creature.[1] The young fig sends down roots to the ground. These roots increase in size, branch and fuse with one another, forming a sort of tight network around the trunk. The combination of the fig's foliage and enmeshing roots interfering with the growth of the tree above and below ground may eventually cause its death. Fig. 9 illustrates a fig commencing to strangle a breadfruit tree; while in Fig. 10 the host has al-

Fig. 9. A young strangling fig commencing to strangle a breadfruit tree. College of Agriculture, Los Baños.

ready succumbed and rotted away, leaving the hollow framework of the fig in its stead. Such a framework may thicken its meshes so as to appear as, and

[1] In Hawaiian forests, Ohia lehua trees usually start their careers exactly as does a young strangling fig. The Ohia seedling, however, almost invariably perches upon a tree fern, which it gradually enmeshes and smothers in a network of roots.—Editor.

perhaps eventually to form, a solid trunk such as the one illustrated in Figs. 11 and 12.

While I observed about twenty species of strangling figs on Mount Maquiling, no individual kind was seen in sufficient numbers to justify any other than very general conclusions about the habits of a few. Thus *Ficus pruniformis* does not appear to develop a large stem, but exists in a vine-like condition except for the

Fig. 10. The hollow framework of a strangling fig. Its host has rotted away. Mount Maquiling.

profuse branching and leafing out at its summit. *Ficus calophylloides* in later life usually has a more or less cylindric and solid appearing trunk, or sometimes a pair of stems fusing higher up (Fig. 13). I believe it is about the finest strangling fig here, sometimes one hundred and ten or more feet tall, with a crown of a spread of one hundred and eighty feet or more and a trunk diameter, several feet up, of five feet. *F. clementis* is another fine tree which reaches a great size.

The form, size, and sturdiness of the host-tree have much to do with the appearance of the fig, as the latter may be said to replace eventually the tree to which it has affixed itself. Thus the great harp-like *Ficus clementis* (Fig. 14) seems to have developed on two trees; Fig. 10 shows a fig shaped on either a bent or comparatively weak host; in Fig. 15 it appears to have sent down roots for further support, these have grown quite thick; in Fig. 3 the *F. clementis*

Fig. 11. *Ficus indica.* Mount Maquiling.

would be expected to develop into a good straight tree, if it should be self-supporting when its host, *Eugenia* sp., dies. In Fig. 16 the strangling fig forms an awkward picture in sending out two long arms from its central host, a bread-fruit tree, but this fig cannot be considered mature and may yet form a rather shapely tree. The crown of a strangling fig is often quite irregular and rather open, its branching not appearing well planned out.

Many of these trees are largely deciduous during the dry season. They do

not appear to interfere more than, or as much as, other large forest trees do with the growth beneath their canopy, and saplings and small trees may occur under them. They are often an improvement in appearance over the host they have killed, and may be said usually to develop a wider crown than the latter, because, in part perhaps, they often branch out below much or most of the branching of the host itself, and the foliage seeks the light both from the sides and upwards.

Fig. 12. *Ficus calophylloides*. Mount Maquiling.

There appears to be hardly any choice of host for strangling figs. Among the trees that I have found them attacking in or near the forest were very often other strangling figs and those of group four, *Eugenia* sp., *Dillenia* sp., *Bischofia javanica* Bl., *Artocarpus communis* Forst., *Celtis*, and *Zizyphus* sp. I think it is a matter of the young fig finding a good starting place, as the crotch of a tree,

a broken and decayed branch on a tree, a crack or hole in the trunk, among leaf-bases of certain palms, etc. Decayed stumps are also accepted, and even cracked stone walls, as I observed in Manila. Rocky banks will sometimes support certain species. Very young baletes are not commonly seen in the forest, though one may overlook them time and again, growing quite unhidden. I think, how-

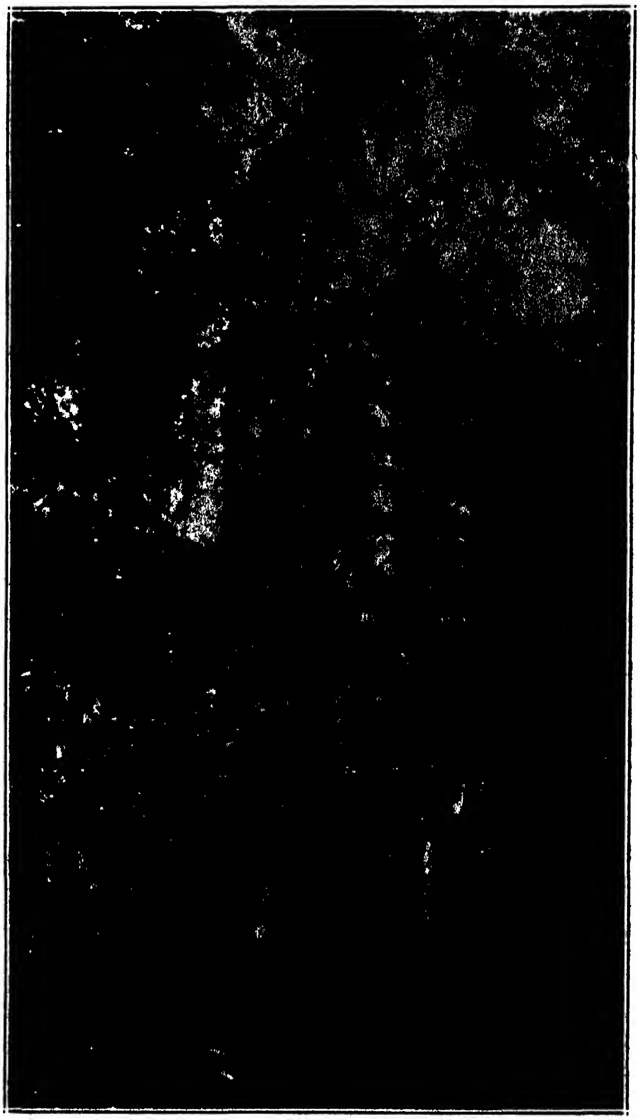


Fig. 13. *Ficus calophylloides*, with double stem. Mount Marivales.

ever, that they usually start their growth high up on trees, where conditions are better and where they would not become conspicuous for some time.

While strangling figs, with proper care, will grow readily from seeds, when planted directly in soil, these seeds are quite small, and hence the tender little plants undoubtedly find the struggle for existence on the forest floor very severe. No sooner has a fig fallen, and even before it has started to decay, than it is at-

tacked by additional insects, and while many of the latter eat the rind only, certain ubiquitous ants carry away quantities of the seeds. I have not yet observed strangling fig seedlings growing on the ground in the forest, and I think that all or nearly all there begin life as epiphytes on trees or tree remains. And yet many thousands of figs, each fig containing often a large number of seeds, fall annually or semi-annually frcm baletes upon the rich soil below.

Fig. 14. *Ficus clementis.* The inside of the inverted V is at least forty feet high. Mount Maquiling.

The fruit of these figs is quite varied and ranges from 5 or 6 to 35 millimeters or more in diameter. More often they are glabrous and globular, though some are ovate or oblong and with or without stems or peduncles. When ripe, some are greenish, others yellow, red, or very dark purple. The large ripe figs of *Ficus calophylloides* have a very pleasant nectarine odor, easily detected from some little distance; those of *Ficus camarinensis* are scented somewhat like a

prune or plum. Their flavor, however, is far inferior to the perfume and I have found none pleasantly edible. Besides possessing an inferior flavor, the interior contains a mixture of true seeds, chaff, gall seeds, male flowers, and dead insects. Monkeys, bats, and birds patronize a balete and enjoy a feast for the short time that the tree is in ripe fruit, the latter usually maturing almost all at once.

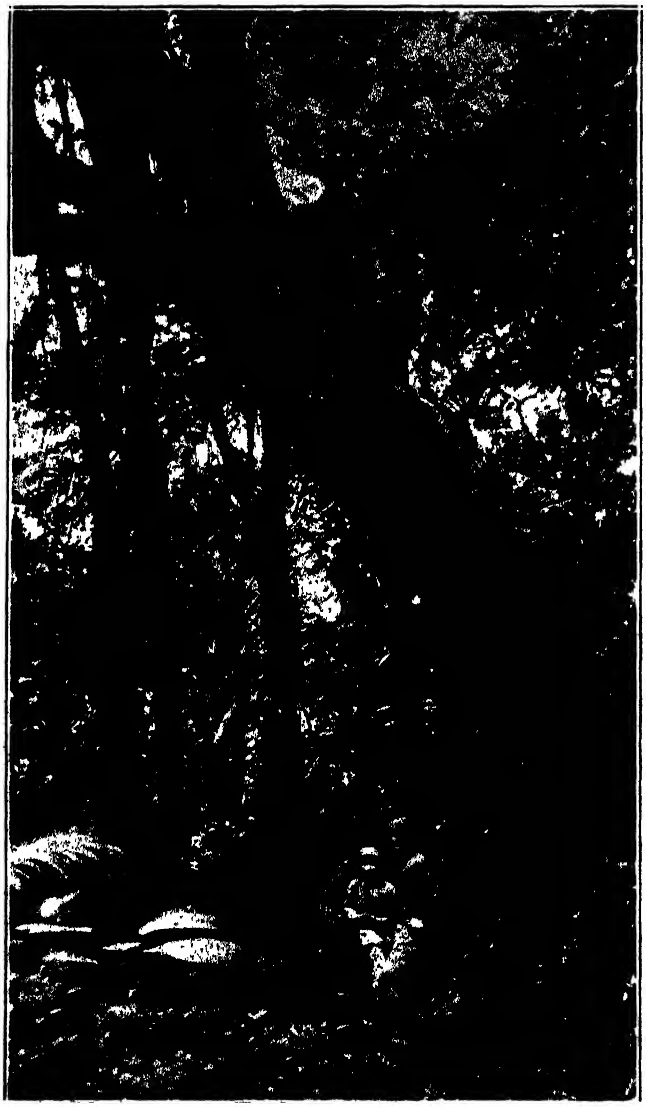


Fig. 15. *Ficus indica* at the edge of the "mossy forest." Mount Maquiling.

I have not seen such a wide variety and perhaps abundance of strangling figs anywhere as on Mount Maquiling. Brown and Mathews, in speaking of Philippine Dipterocarp Forests (Philippine Journal of Science, IX, p. 424, 1914), say that: "These strangling figs frequently occur on the largest trees, but are much less numerous in the best forests than in the poorer types." Thus they abound in the much cut over forest on Mount Maquiling, where there is considerable

light and perhaps more available starting places for the seeds than in those areas where a better and more uniform stand of tall trees prevails. It is to be noted, however, that strangling figs are also plentiful on Maquiling well above the culled forest, and this also seems true of Mount Marivales. As an example of their abundance on Mount Maquiling, I found three trees within a radius of thirty feet supporting altogether seven specimens of baletes, apparently all different species. The three trees concerned were one medium-sized *Eugenia calubcob* C. B. Rob. and two large Tuai, *Bischofia javanica* Bl., and one of the latter supported three species of figs. Such crowded abundance, however, is perhaps unusual, but it is very common to find one host supporting two species of figs, and probably the oldest fig becomes a host later on.

On the flat lowlands about Los Baños I have not found these figs on trees under cultivation, except for a single very youthful example in an old wound

Fig. 16. *Ficus* sp. strangling a breadfruit tree. College of Agriculture, Los Baños.

on the stem of a royal palm (*Oreodoxa regia* Hbk.). I have twice noticed them on breadfruit trees (*Artocarpus communis* Forst.), but never on the mango (*Mangifera indica* Linn.).

In city parks young indigenous figs may gain a lodging on trees or palms (Fig. 17). One day while in Manila I made it a point to investigate this phase of the subject. The commonest strangling fig grown in Manila is probably *Ficus elastica* Roxb., and that species not being a native has no fig pollinating wasps and consequently no fertile seed to produce offspring. *Ficus concinna* Miq. is one of the few baletes that occurs in or about Manila. It was noticed in only two parks, the Botanic Gardens where no small ones were seen, and in Plaza McKinley, Intramuros District. This little plaza is very small, with the park itself about 150 by 175 feet. It is a well-kept place of lawns, shrubs, and trees, and of the latter most are legumes. There is one fine *Ficus elastica* and five in-

dependent trees of *F. concinna*. From *F. concinna* seeds nine little ones had been produced and were growing as epiphytes, three on date-like palms and the remaining six on leguminous trees, some apparently belonging to the genus *Delonix*. All were on individual hosts and ranged from about ten inches to two feet high. They occupied such places as a dead branch broken off close to the trunk, in the hollow between the trunk's branches where some humus had gath-

Fig. 17. A young *Ficus concinna* (upper left) on a palm in Manila.

ered, or among the leaf-bases of palms. None of these young baletes appeared to be in a flourishing condition, but the mature *F. concinna* struck me as an improvement over their neighbors, the leguminous trees.

In such city parks and gardens strangling figs may show to better advantage than those growing in forests. The city fig is planted from a seed or cutting. From the beginning it has plenty of light and elbow room, and not start-

ing as an epiphyte, grows erect. I found it noticeable that the forest balete, having to struggle for light and space, very seldom has branches curving close to the ground or twigs arising low on the trunk, as do many cultivated ones and those growing wild in open country. Their fruits then, except when fallen, are usually inaccessible to a person standing on the ground. Thus, the services of a forest guard, F. Canicosa, an expert scansorial artist, have been of very great value to me in this work. (Fig. 18.)

Fig. 18. Forest Guard, F. Canicosa, who secured all "inaccessible" figs for me. The large tree is *Ficus clementis*. Mount Maquiling.

The fourth group of figs is a very large one and comprises usually medium to small-sized trees or shrubs. Here belong the somewhat edible figs of this locality as well as those of commerce. The male and female fruits are on separate trees; thus the true seeds having a whole receptacle to themselves are very numerous, and seedlings are not infrequently found, though comparatively few

survive. These trees favor a great variety of situations; some are best represented in the lowlands, a number are to be found in the cool upland woods, while others enjoy a wide range in altitude. None of them are stranglers, and several are quite ornamental and excellent shade trees. Some are very hardy and more or less resistant to fire, in that they will send forth suckers from their base.

Fig. 19. *Ficus pseudopalma.* Large specimen at Forest Station, Los Baños.

This is probably truer of the more scrubby varieties, such as *F. ulmifolia* and *F. hauili.*

Ficus pseudopalma Blanco (Fig. 19), with its slender palm-like unbranched stem or stems and its long ragged leaves crowded at the summit, is certainly an aberration in the genus. It seldom exceeds a height of twenty-five feet and is fairly common in portions of the cut-over lowland forest. It is often burdened with vines. The rather large figs, wedged in at the base of the leaves, are fairly

good eating. This tree, perhaps, is more infested with disagreeable ants than any other species with which I am familiar. It also bears the distinction of having the largest *Blastophaga* wasps, as well as seeds, of any fig that I know of. The species is distinctly ornamental.

Ficus minahassae Miq. is common along streams of the lower levels and also extends to fair elevations. In Benguet Province to the north it occurs up to an

Fig. 20. Specialized fruiting branches or "tubercles" of *Ficus minahassae.* Mount Maquiling.

altitude of 5000 feet. It has a graceful form and a very wide crown, so that it is quite often broader than high. Several may occur together and cast a fine shade. Fig. 20 shows the specialized fruiting branches or tubercles. The female tree bears in clusters on these tubercles many very small but juicy figs, which, while pleasantly sweet, have little flavor. They are quite attractive, however, to small birds. This species bears several distinct crops a year, and while there

may be a great deal of germination among the fallen fruits, I have found a very small percentage of survivals in the young plants. *Ficus minahassae* is remarkable in the genus not only for its very long specialized pendulous fruit-bearing branches, but also because it is the only species in the genus where the small figs are crowded into more or less globose glomerules. By Miquel it was made the type of a distinct genus. It occurs throughout the Philippines; otherwise it is known only from Celebes.

The common Tibig, *Ficus nota* Merr. (Fig. 21), is often conspicuous for its ample bunches of large figs, Fig. 22, which occur along trunk and branches. It is a small tree but an important element in many places along lowland streams and in cut-over lands. It has large leaves and is a good shade tree, though probably short-lived. Its fruits, which are often over two inches in diameter, may be purplish in color, but usually greenish or yellowish-green and brownish. They

Fig. 21. *Ficus nota* in a newly-cleared area. Mount Maquiling.

are quite unpalatable. Seeds of this fig can be secured in quantity. I have also found *Ficus nota* at an elevation of about 3000 feet on Mount Maquiling.

There are many other cauliflorous species more or less similar to *F. nota*, of which the "Tangisan buyawak," *Ficus variegata* Bl., growing in the forest, is about the largest.

Perhaps the commonest fig growing in waste places of the lowlands is *Ficus ulmifolia*. It is scarcely more than a shrub and appears more subject to the attacks of insect borers, leaf- and fruit-feeders than any other species. The fruits are numerous and the female ones edible.

Ficus hauili is another shrub or small tree with much the same habitat as *F. ulmifolia*, but it is a handsomer plant, with shining green leaves. It extends a short distance into the forest. The fruit of *F. hauili*, as well as that of *F. nota*, insipid as they are to us, form a favorite food for certain frugivorous bats.

In the lower levels of the regions visited there is really no cold weather, while the dry season is not of a very parching nature. Hence the various figs may and do bear, more or less, throughout the year. For while a certain individual plant may not be expected to fruit for six months or so, as seems to be common among strangling figs, another individual of the same species may be in full bearing at this period, a third might have young fruit, and so on. This

Fig. 22. *Ficus nota* in fruit. Mount Maquiling.

was observed with several species, as *Ficus calophylloides*, with crops on different individuals representing December, March, May, and so far, July or August, and with *Ficus* sp. whose fruiting period occurs in many months. A single individual of the latter species has already borne two crops, one in January and the other in June, with some still small and green fruit accompanying the latter crop. In group four, there appears to be a closer succession of crops. One tree of *F. minahassae* has, up to the present, borne a crop in December, March, and July, the young figs literally pushing their elders off their perches. A female *Ficus ulmifolia,* until recently, has had fruit in all stages for several months. *Ficus*

nota usually starts another crop as scon as the mature figs drop off. A single tree may also have a quantity of fruit in different stages.

Fig trees have many enemies and many patrons. In fact the fauna attached, habitually or otherwise, to species of the genus *Ficus* would make a study in itself. Weevils, moth caterpillars, and fly larvae infest the fruit, beetle borers attack the soft wood, and a large assortment of insects damage the leaves and twigs. Various bugs suck the juices of the fruit, and scarabeid fig beetles are

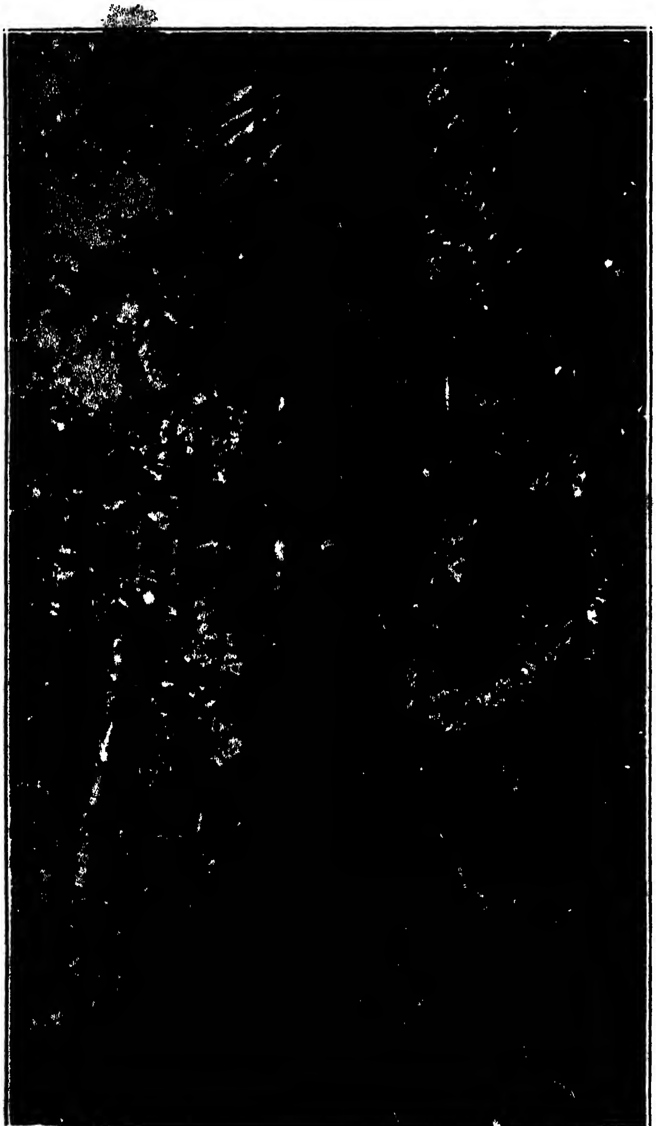


Fig. 23. *Ficus integrifolia.* Mount Maquiling.

common, as on *F. ulmifolia,* for example. The seed production is interfered with by some gall wasps which, in producing galls of their own, crowd out the true floral parts. Fruit-flies, I do not believe, have been reported as attacking the sound fruit in this region. Monkeys, bats, hornbills and other birds frequent certain species of figs when these are in ripe fruit.

In conclusion, it may be suggested that figs of groups one and two are not very important forest elements. Figs of group three are a conspicuous element and usually thrive where they can reach water. They grow well up to 3000 feet or more. Perhaps not all of the species would make desirable introductions if their respective fig-wasps were to be introduced later. This would probably apply more to the vicinity of towns and parks.

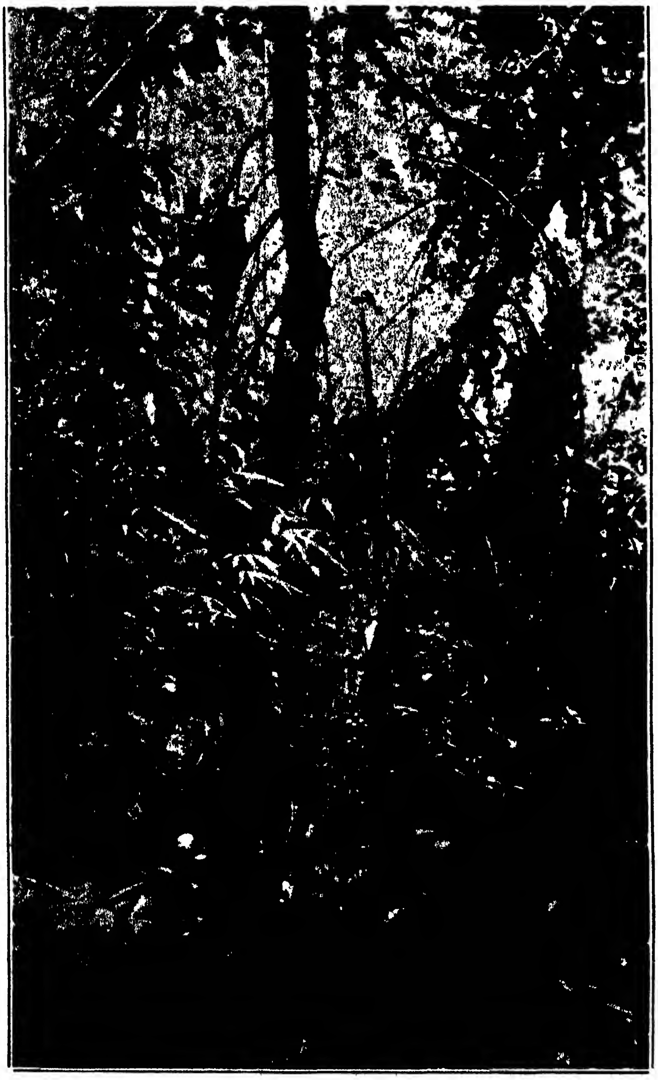


Fig. 24. *Ficus mindorensis* in fruit. College of Agriculture, Los Baños.

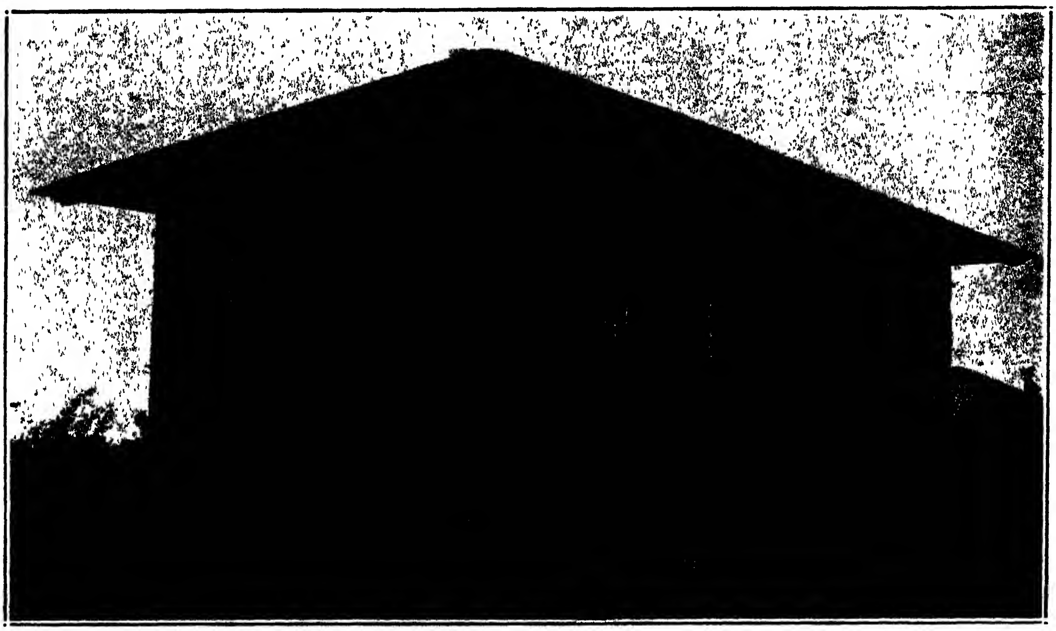
Strangling figs do not appear to be pests here as certain ones are in some other portions of the Orient. Some Philippine species, no doubt, would prove useful, both as shade and ornamental trees. Group four contains several desirable forest trees, from a point of forest cover, and I think that the fig-pollinating wasps of such species as *Ficus nota* and *F. minahassae* could be brought into Hawaii without much difficulty.

The Hawaiian Sugar Planters' Insectary, Los Banos.

As an expression of appreciation for the cooperation extended in entomological work, the Hawaiian Sugar Planters' Association, in January of this year, presented the College of Agriculture of the University of the Philippines the insectary shown here.

"The 'Hawaiian Sugar Planters' Insectary,' so labelled over the door, is up and ready for business," writes C. F. Baker, Dean of the College, to F. Muir. "You will note that the supporting posts are set in cement with a deep furrow about each post for insulation against ants. For the same reason, the landing above the steps is entirely disconnected from the building.

"The building is very commodious, window tables all around, a large re-



ceiving table in center, water installed with special provisions for drainage. Altogether it is one of the best things of the sort in the Orient, and I believe that both the Hawaiian Sugar Planters and the College of Agriculture are to be warmly congratulated. May it be equally of service to both entities!"

It will be recalled that our entomologists made their headquarters at the College of Agriculture at Los Baños during much of the campaign that resulted in the successful control of the Anomala beetle by the Scolia wasp.

The suppression of the pest has meant thousands of dollars to the sugar industry of these Islands. Had it spread unchecked, its damage by this time would have reached serious proportions.

While studying *Ficus* insects and wireworm parasites, F. X. Williams is now making his headquarters at Los Baños and is enjoying the facilities of this insectary.

The Betterment of Industrial Relations.

A Message to the Plantation Skilled Employees.

By Donald S. Bowman.

The betterment of industrial relations is one of the problems constantly before the plantations of Hawaii nei. It is our wish to improve general living and social conditions in a sane, practical manner, going as far as finances and good judgment permit in order that those residing on the plantations may lead a healthful, contented existence.

If we are to improve morale, and it is vitally necessary that we do consider morale, for no battle was ever won except where there was good morale, it is essential that we consider the working and living conditions of our employees. Their health, recreation, religious and social life cannot succeed in the largest sense without guidance and help from the plantation skilled employees.

If plantation industrial service work is carried on in the proper spirit, the result will be a contented people working for the best interest of the plantation.

We do not wish the plantation skilled employees to feel that the industrial service work, which includes all of the so-called welfare work, is paternal in character, and that the plantation is handing them out these things to create loyalty. Just the opposite is true. The plantation realizes its duty to the people residing within its boundaries, and since the first plantation was established it has been the custom to provide free medical treatment, houses, etc.

As in other parts of the world, conditions have changed, and we, who have the reputation of leading the world in up-to-date sugar production, must also keep abreast of the times in that most important branch of our work, the improvement of our man power. We have spent much time and money in perfecting our mills, in the improvement of farm machinery, the propagation of cane, the control of pests, etc. The man power work which has to do with the improvement of morale rests largely with you, the skilled employees of the plantations. Do you realize that we all look up to leadership and that someone is going to lead the laborers? That someone should be the skilled employee. The personal touch between the skilled and unskilled should be fostered and maintained. Where this personal touch is not maintained the labor leader or agitator gets in his work. The real thing that keeps the labor leaders in their position is the inactivity of the skilled employees, who lack personal interest in the men employed under them.

As the plantation manager is a link in the chain between the skilled employees and owners, so is the skilled employee a link between those below him and the manager. Managers must engender loyalty, cooperation, and interest; so the skilled employees must not only have these ideas, but should advocate them in their daily contact with the laborers.

Our labor problems will be solved only when the laborers are interested in their work and feel right toward the plantation employing them. This can be

brought about only by an improvement in personal relations between the skilled and the unskilled.

Let me tell you what I gathered after a lengthy talk with Mr. Dumas, manager of the Calambra Sugar Company in the Philippine Islands. Mr. Dumas employs Filipinos as labor, semi-skilled and skilled. He also employs white men to fill the higher positions on the plantation. He maintains that to be successful with the Filipinos one must show a personal interest in them, and he places more importance on human relations than anything else. In order to develop human relations and an interest in the plantation he has his laborers formed into companies of thirty men, each in command of a Filipino. Four of these companies form a battalion, in command of a white man. The company commanders are the lunas and the battalion commander is the section luna. The lunas are held responsible for the men turning out to work, and they must investigate every cause for absence, reporting the same to the section luna. If a man lays off without a satisfactory excuse he is personally interviewed by the section luna. The section luna keeps a record of the work of each company, and this record is posted daily. Section lunas are encouraged to learn the names of all men under them. Prizes are given weekly to the best gangs. All lunas go to and return from work with the men, generally marching to and from the fields. The white employees mingle freely with the Filipinos, playing and encouraging them in their games, which develops a good morale.

In going over the matter of handling the Filipino with Mr. Dumas, I gather that these are the essentials as he sees them:

Personal interest in the man makes him realize that you are his friend. Human relations,— show by your actions that you are interested in him, his family, his home, and his life.

Promote interest and contact between the whites and Filipinos. Encourage the whites to take an active interest in sports and amusements carried on by the Filipino. He needs help and encouragement. Arrange for contests and entertainments to keep down labor turnover.

Provide plenty of water and wood, and a place to raise pigs and chickens.

Promote him to semi-skilled and skilled positions if he can fill them.

Develop leaders and you will know all that goes on. There will be no labor troubles.

Filipino nurses are of the greatest help and are depended on to assist in the morale work. They are treated on the same level with the skilled. Their standing should be such as to have the laborers look up to them with respect.

Consider always that the Filipino is unduly suspicious. You must deal honestly and firmly with him.

We find that the ideas of Mr. Dumas are along the same lines of those of Mr. Varona.

We must consider that anything we do that will tie together labor and industry is well worth while. It costs money to train new men, and even though they be laborers, the most valuable man is the one who remains on the plantation, turning out daily. Nothing that can be done will entirely prevent men from moving from one place to another. It is impossible to compete with those who are offering higher inducements, but we can create conditions that will make a

more contented people and develop team-work and cooperation. We are doing these things and striving to create in the labor a morale that has faith in the plantation.

Here in Hawaii nei, as on the mainland, the day of the big stick in industry has passed, and we have learned the better way of handling our labor with human consideration and relations.

The most successful work on any plantation that has for its purpose the betterment of plantation social and living conditions, is the work that is carried on with the cooperation of the skilled employees. Lacking this interest you will find a larger turnover and discontented people. No matter what activities you have under way which have for their purpose the entertainment of the people, there must be some supervising head, and that person is the one who needs your help and interest in the activities that are being put over.

Community or plantation interest is a wonderful thing to develop, as it makes life more interesting and livable for all. The things most enjoyed for the amusement of the old as well as the young are the sports and entertainments carried on by the people themselves under proper supervision. These activities should be self-supporting.

In supervising industrial service or welfare work we must get away from the idea of paternalism and consider that it is part of our business to create better conditions, and that this work can be carried on with success only with your help, as the interests of the plantation are your interests.

The temptation in welfare work is toward being too paternal. When I say this I have in mind the instructions sent a film distributor by an industrial service worker who had charge of a platnation theater. "Send me no films of society drama, no films that show any shooting or crime, no sex appeal pictures, no comedy showing ladies in tights." What did he have left to choose from? In this connection we are led to a consideration of censorship, a mighty delicate thing to handle. We can, however, use only films passed by the National Board, which assures as clean films as are produced. It is dangerous to have some local authority decide what is best for our mixed plantation population.

I know of no one on any plantation who could be trusted to assume the moral responsibility for the people who patronize the plantation showhouses. The people must decide for themselves to a very large extent. No local censor will be able to satisfy our movie patrons.

Local censorship has been tried. It doesn't work. The results are continued dissatisfaction and lack of patronage of the locally censored playhouse. The young and innocent must be protected, and this protection rests with the parents. However, a general insistence for cleaner, better films has resulted in a marked and growing improvement. The community must decide what it wants, and these decisions can best be brought out by the skilled employees cooperating with the labor.

The employees of the plantations who are engaged in service work for the people, such as the doctor, nurses, and industrial service workers, are employed to render service to the people, and not to relieve the skilled employees of their work and interest in building up a better community. It is necessary at times for the service workers to resort to publicity to awaken plantation interest, for

by publicity all of the people will become interested in the work of creating a better community spirit. No matter what work we are engaged in, we need help, and how can others help us unless they know what we are doing? This is especially true on the plantations, as no service or welfare work can be operated to obtain satisfactory results unless the activities are backed up by the interest and cooperation of the skilled employees.

After a consideration of the psychology of the various racial groups which furnish us with labor, we have concluded that discontent is not so much a matter of wages as it is a state of mind, or morale, and we believe that every plantation can develop and carry on morale improving work to its great advantage.

The world's economic history teaches us that men are seldom content with what they have. Their wants are limited only by the production of satisfaction. Wants generally multiply from other wants. It rests, then, with us to produce satisfaction, which can be done to a large extent by providing good community life and working conditions. This calls for the hearty cooperation of all plantation employees.

Bud Variation in the Sugar Cane.

That there has been interest in former years in the possibility of improvement of cane through selection of mutations is evidenced by this article, that appeared in 1902 in the International Sugar Journal, reprinted from the West Indian Bulletin, which tells of the work of that day. It remained; however, for the investigations of 1920 and subsequently, based on the improvement of citrus fruit, to reduce the matter of cane improvement to a systematic basis.

Careful observations and exact measurements have shown that amongst animals and plants no two individuals are exactly alike. That this is so amongst human beings and domestic animals is indeed a matter of common observation, and it is by these individual differences that we are able, for example, to recognize one person from another. Amongst plants similar differences, although not so noticeable to the non-critical observer, exist nevertheless. "In every bed of flowers or of vegetables we shall find, if we look closely, that there are countless small differences, in the size, in the mode of growth, in the shape or color of the leaves, in the form, color, or markings of the flowers, or in the size, form, color, or flavor of the fruit. These differences are usually small, but are yet easily seen, and in their extremes are very considerable; and they have this important quality, that they have a tendency to be reproduced, and thus by careful breeding, any particular variation or group of variations can be increased to an enormous extent—apparently to any extent not incompatible with the life, growth, and reproduction of the plant or animal."[1]

[1] Alfred Russel Wallace, Darwinism, 2nd Ed., p. 84.

This tendency to variation occurs amongst plants in a state of nature, and is very pronounced indeed in many cultivated plants. In particular is it to be noted in those plants which are grown on a large scale and in widely separated countries, so that they are exposed to very varied conditions of soil, climate, etc.

The sugar cane exactly fulfills these two conditions, being cultivated on a very large scale and in very distant countries. It has been cultivated for so long that its actual origin is doubtful, but the available evidence points to all the sugar canes grown commercially belonging to one species, *Saccharum officinarum* Linn.

In addition to the favoring factors of extensive cultivation under varied conditions, it has also had the advantage of time, so that it is not surprising to find the sugar cane at the present day represented by countless varieties, differing widely from one another in many characters. Habit, color, vigor, resistance to drought and disease, time of flowering, time of ripening, sugar contents, all vary to a considerable amount. The constant aim of sugar cane cultivators in every country is, or should be, to select those varieties which possess desirable characteristics to the greatest degree.

In actual practice two methods are known and made use of to obtain new varieties of plants, namely, by taking advantage of (1) Seed or seminal variation, and (2) Bud variation.

By the phrase "seed or seminal variation" expression is given to the fact that the seedlings of a batch raised from the same parent plant will differ, both from one another and from their parent plants in various respects. "Some naturalists have maintained that all variations are connected with the act of sexual reproduction; but this is certainly an error; for I have given in another work a long list of 'sporting plants,' as they are called by gardeners—that is, of plants which have suddenly produced a single bud with a new and sometimes widely different character from that of the other buds on the same plant. These bud variations, as they may be named, can be propagated by grafts, offsets, etc., and sometimes by seed. They occur rarely under nature; but are far from rare under culture."[2]

Previous to the independent discovery by Messrs. Harrison and Bovell in Barbados, and Dr. Soltwedel in Java, of the formation of fertile seed by the sugar cane, the first method of raising new varieties was impossible, or at any rate could not be knowingly practiced. It is quite possible that some seedlings may have come up in fields and by chance have got into cultivation. But no organized selection of desirable plants from amongst a batch of seedlings, as is today carried on, could be made. The discovery of the seed rendered this mode practicable; its value was recognized at once, and the success with which the work has been carried on may be estimated by the fact that in the West Indies, at any rate, "seedling canes" have, in many localities, supplanted to a large extent the older varieties. In the sugar cane experiment stations in Barbados alone there are now about six thousand seedlings under experimental cultivation.

The occurrence of the phenomenon of bud variation in the sugar cane has so far been little noticed, and even at times doubted. Messrs. Jenman and Har-

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[2] **Charles Darwin, Origin of Species, 6th Ed., p. 8.**

rison, in their *Report on the Agricultural work in the Botanic Gardens, British Guiana,* for the years 1893–5, write:

"We have no faith whatever in the suggestions often thrown out to select the most saccharine canes of any distinct variety for planting out, as in every stool of canes considerable differences invariably occur in the saccharine strength of the canes, due solely to differences in age and position in the stool and other influencing conditions. We do not consider that a cutting from an older or otherwise favored richer shoot is likely to produce a new plant of superior saccharine strength, and as a matter of fact all our experience disproves this oft recommended idea, and we know of no analogy supporting it apart from seminal generation, no instance of 'bud variation' having ever occurred in our long daily acquaintance in field and laboratory with the cane."

In 1897 Professor J. B. Harrison, in his work on *The Results of Recent Scientific Researches into the Agricultural Improvement of the Sugar Cane* (p. 11), says: "Until recently this mode (bud variation) of attaining an improved variety of cane appeared to be a favorite one with the authorities at Kew. By 'bud variety' is meant the production of a variety distinct from that of the parent cane by means of a shoot springing from an eye. As the search for these 'bud variations' has been recommended by such high authority it is of some interest to ascertain on what grounds the assertion that 'bud variation' occurs in the sugar cane is based. Neither Mr. Jenman nor myself, during our long individual experiences with the scientific observation of the sugar cane — experience probably as extensive as that of any other scientific observers — has ever seen anything resembling a 'bud variation' in the case of the sugar cane, and I think that we are justified in assuming that if such variation ever occurs it is only in exceedingly rare cases."

And further (p. 16): "I do not consider that the improvement of the sugar cane by means of bud sports can be considered as a practical method, or one likely to repay the enormous amount of work necessary to search through many square miles of sugar canes in search of what, at the best, must be of extremely rare occurrence."

Apparently, therefore, no cases of bud variation in the sugar cane had been recorded from the West Indies previous to 1897. The phenomenon had, however, been observed and taken practical advantage of in other countries. In December, 1890, Mr. John Horne, then Director of Forests and Botanical Gardens, Mauritius, in a letter to the Director of the Royal Gardens, Kew, published in the *Kew Bulletin* for 1891, says:

"Raising canes from seed to get improved varieties will be a long and tedious affair, and there will be many disappointments before a really good hardy sugar-yielding variety will be obtained. I think it probable that more and better results will be obtained by good cultivation and by new varieties from bud sports. Of these last we have eight or nine in Mauritius alone; some of them are very fine canes and they are extensively planted. Most of them are hardier than their parents and yield more sugar. They are mostly obtained from new canes recently introduced. The sudden change of climate, soil, and other circumstances causes them to be thrown off. More of them might be obtained if the planters were more observing than they are and closely followed the cane cutters when

cutting the canes. Thus they would range all their fields over, perhaps areas amounting to 1,500 acres, matching each cane as it is seen cut. As things are, a new variety is only observed should it chance to spring up in an outside row."

Dr. Dubbs also, in his book on the *Sugar Cane*, the preface of which is dated June 30th, 1897, records (p. 66) the following experiments carried out in Louisiana:

As an illustration of bud variation, eight years ago some stalks of cane, partly white and partly purple, were selected from the field of Soniat Bros., Tchoupitoulas plantation They were called by them bastard canes. These stalks were taken and planted as follows: First row, the entire stalk; second row, the white joints of each stalk; third row, the colored joints of each stalk. At the end of the season four distinct canes, as far as color could direct us, were obtained. Types of the four new varieties were selected and separately planted, and the next year were found to be nearly pure. Selection and separate plantings have been made each year since. These canes have been named as follows: First, a white cane, No. 29, Soniat, after the owners of the plantation; second, a light striped, No. 59, Nicholas, after the then Governor of our state; third, a light purple, No. 64, Bird, after the then Commissioner of Agriculture; fourth, a dark striped, No. 65, Garig, after the other member of the Board of Agriculture. The yield and analyses of these canes have been annually made. They, except the white, are entirely different from any other cane in our collection.

"They are now permanent canes in our collection, and with the exception of the striped varieties, which have the tendency of all ribbon canes to vary under cultivation, are fairly permanent in their typical characteristic, viz., color. Their sugar contents are fully equal to those of our home ribbon and purple canes, over which they have as yet no pronounced excellencies. They are cultivated as evidences of bud variation."

In view of the fact that no cases of bud variation in the cane have, apparently, as yet been brought to notice in the West Indies, it is desirable to put on record two instances which have recently come under observation.

The first case was forwarded to the Department of Agriculture by the Hon. F. J. Clarke, from Kirton plantation in Barbados, and exhibited by Dr. Morris at a meeting of the Barbados Agricultural Society in April, 1899. The specimen in question was a ribbon or striped cane, the ribbon being well pronounced on the main stem. Four successive joints had thrown off shoots, the first and third of which were striped with red like the parent cane, whilst the second and fourth were unstriped, yellow canes. Four following joints, therefore, on one cane, bore alternately striped and unstriped shoots. The resulting appearance was a striped parent cane bearing, on the one side two striped shoots, and on the other side two unstriped shoots.

In March of the following year Mr. S. B. Kirton, proprietor of Arthur Seat plantation, Barbados, observed several clumps (stools) of cane showing bud variation growing in the hedge-row of a field on his plantation. This field was examined with very interesting results.

In the case described above it will be remembered that one individual cane had given rise to side shoots, some of which were striped and some unstriped. In the Arthur Seat canes the variation had arisen earlier in the plant's growth,

and the whole canes, as they sprung from the ground, were either striped or not. A single clump dug up had a most striking appearance. From a common base sprang, on one side red striped canes, and on the other side pale yellow unstriped canes.

The examination of five clumps in which the phenomenon was noticed gave the following figures:

Clump	White Canes	Red Striped Canes
A	6	6
B	9	6
C	6	4
D	5	6
E	1	16

One of the clumps was submitted to J. R. Bovell, who reported: "After careful examination I am satisfied that in this clump of canes there is a decided case of 'sport,' or bud variation, as the piece of cane originally planted was a bit of ribbon. From a bud of this ribbon cane there was produced a white cane, which in turn produced from a bud below the surface of the ground a ribbon cane.

"A curious circumstance in connection with this case of bud variation, is the resemblance of the white canes to the Burke seedling cane.

"As you know, Mr. Webster, the manager of Arthur Seat, when showing you the clump pronounced the canes to be 'Ribbon and Burke,' and certainly the resemblance is so great that had I been shown the white canes and been asked to what variety they belonged, I should have said the Burke."

Subsequent to these observations in Barbados, James Clarke of North Queensland, in a letter to Professor J. B. Harrison (for a copy of which we are indebted to him) records the following interesting facts:

"Regarding bud variation, I may say that the first time I noticed this was in New South Wales, where I had charge of a large sugar plantation. At that time the 'gumming' disease in sugar cane was at its height, and the cane called Striped Tanna came suddenly to the front as a hardy, healthy, disease-resisting variety.

"A few hundred-weights of this Striped Tanna cane were received and planted out on the plantation I had charge of, and when cutting those canes for plants at eleven months' growth, I noticed here and there a few thin, weakly-looking stalks, quite yellow, and also some purple colored ones without any stripes. Now, as I had planted these few hundred-weights of striped canes with my own hand, I knew for certain there could be no mixture of varieties, and I was more convinced of this later on by finding a stalk from amongst the striped canes with the three lower joints next the ground striped like Striped Tanna and the upper portion of the stalk unstriped and completely yellow. On seeing this I kept all the thin yellow stalks, and also the purple ones, and planted them out separately, and the resulting canes from those plants came up true to color. I

also planted the striped lower joints of the cane, that were half yellow and half striped, and the cuttings from the upper yellow portion separately, and got yellow and striped canes from the respective plants, according to color of cuttings planted.

"When cutting Striped Singapore canes here the other day, I came across what appeared to be ripe yellow Rappoe canes growing out of the middle of the Striped Singapore stools. At first I thought these stalks must have sprung from Rappoe cuttings planted amongst the Striped Singapore canes, but on closer inspection I could see at once that this was not the case, and that those yellow canes must be sports of the striped variety, for after a little further search I found stalks with purple stripes on a few of the lower joints, whilst the upper half or remaining portion of the stalk was of a uniform yellow color.

"Again, to make sure that the yellow canes growing from the center of the Striped Singapore stools were true sports, I dug up a whole stool of mixed canes and sliced the roots through the middle, so as to expose the connections of the different stalks. It could then at once be seen that the striped canes were the parents of the yellow shoots which had sprung from them."

The above scattered observations may be shortly summarized thus:

1. Bud variations occur in the sugar cane.
2. They have been recorded from widely separated countries — Mauritius, Louisiana, West Indies, and Queensland.
3. The differences between sport and mother plant are often as considerable as those between recognized distinct varieties of the sugar cane.
4. Bud variation may give rise to:
   (a) Differently colored side shoots on one cane.
   (b) Differently colored canes in one stool springing from the same mother plant.
   (c) A cane with some joints striped and some unstriped.
5. Plants grown from cuttings of the sports tend to come true to color.
6. The cane giving rise to sports, whenever recorded, has been a striped or ribbon cane.

That bud variation is probably not a very rare phenomenon in the sugar cane is demonstrated by the case of Arthur Seat plantation. The instances mentioned from that locality were the result of merely one afternoon's observation, and of the canes along the hedge-rows of one field only. Close observation, particularly at cutting time, as suggested by Mr. Horne, would probably result in many more cases being brought to light. Whether many more instances will be brought to notice or not will depend in the main on the planter. No one observer, however diligent, can closely examine a large area of canes. The labor of getting about, in amongst the mature canes, is too great in the tropics, and he will be limited to those canes which happen to occur along the edges of a field. That this is indeed the case is shown by the instance of Messrs. Harrison and Jenman, who, during all their long experience with, and careful observation of, the sugar cane, had not, at any rate up to 1897, ever seen a case of bud variation in the field.

Beyond the interest which attaches to these observations so definitely proving the occurrence of bud variation in the sugar cane there is the question of their possible economic importance. Previous to the discovery of the seed of

the cane, the use of bud variation, or sports, was recommended by the Royal Gardens, Kew, as a possible means of obtaining new and improved varieties of the sugar cane.

Dr. Morris, in exhibiting the Kirton specimen at the Barbados Agricultural Society, laid stress on its possible economic value. One of his principal reasons, he said, for coming to the meeting was to try to rouse the interest of the planters and get them to look for specimens. If they had a very hardy cane, disease-resisting, and so on, giving out sports, it was quite possible by cultivating a large number of them to get a cane possessing qualities superior to the mother cane. Again, at the meeting in July, 1899, he said that there was a distinct value in these sports, as they afforded a means of obtaining a cane of greater merit than at present. He wished to impress on the Society that the production of sports was not a mere question of curiosity; it was one of very great importance to the Society, affecting as it did the raising of new canes.

The evidence so far available tends to show that many of these sports possess distinct advantages over their parents. It will be remembered that Mr. Horne says (loc. cit.), on the result of his experience in Mauritius: "Most of them are hardier than their parents, and yield more sugar." Mr. Clarke, at the end of his letter, an extract from which was given above, says: "In conclusion I may say that I have also noticed that the yellow sports have a tendency to grow sweeter than the colored canes of the same family. On analyzing purple and yellow sports of the Striped Tanna canes last week, the latter, grown in the same field and under similar conditions and receiving exactly the same treatment as the former, showed double the percentage of P. O. C. S."

In Louisiana, on the other hand, "Their sugar contents are fully equal to those of our home ribbon and purple canes, over which they have as yet no pronounced excellencies." (Dr. Stubbs, p. cit.)

Having regard to the possible value of the sports recently obtained in Barbados, it was very desirable that they should be submitted to a strictly comparative test. To this end they have been planted out at Dodds and at Waterford plantation, in the same fields with other canes undergoing test. In each case the plants from the striped and unstriped canes are growing side by side. On examining them on August 15th, 1901, they were still too young to display fully their mature characteristics, but gave every indication of producing striped and white canes, respectively.

In the coming crop season, about May, 1902, they will be cut, crushed, and analyzed, and the full results published.

Studies in Indian Sugar Canes.

*Tillering or Underground Branching.**

By C. A. Barber,

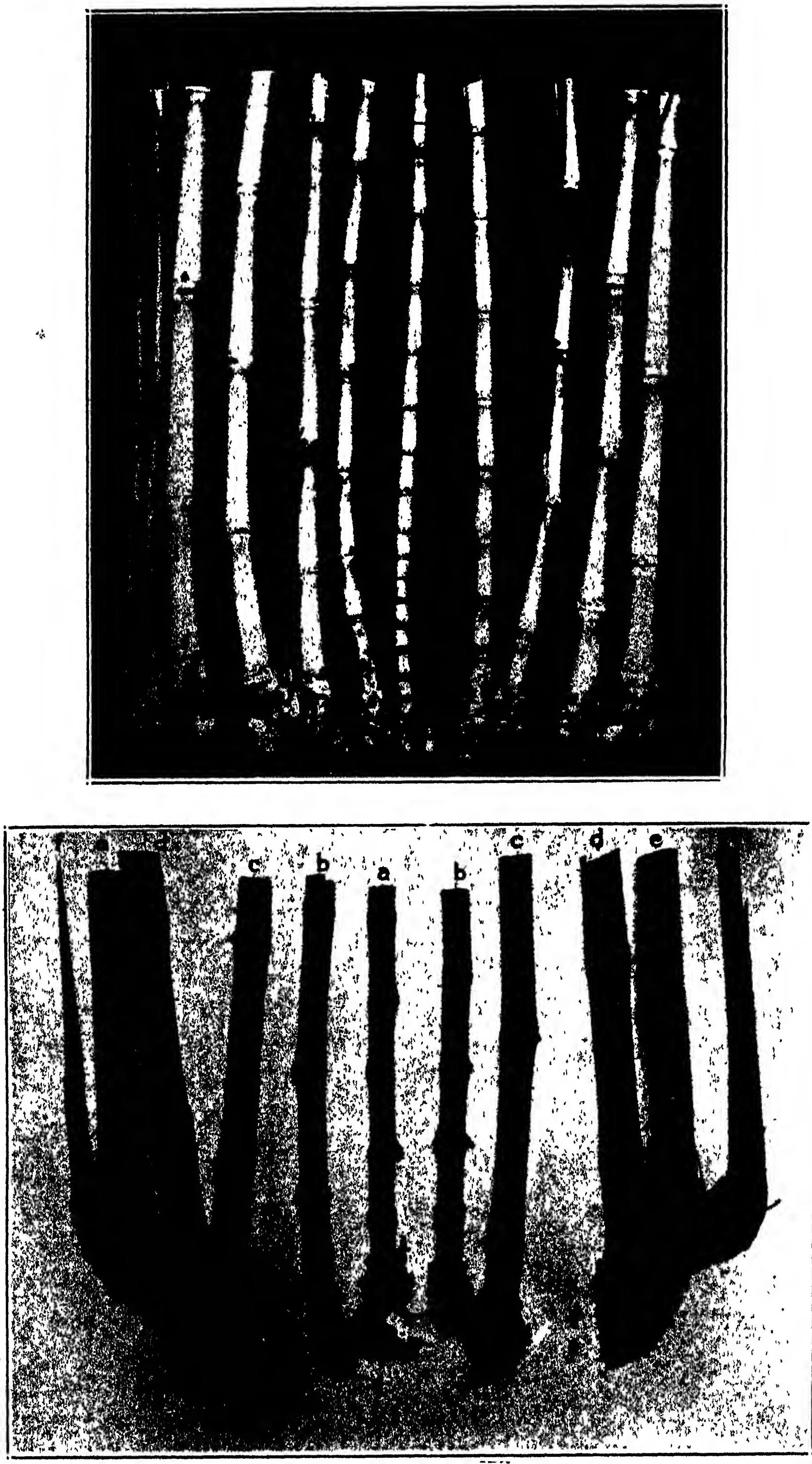
This paper deals with a detailed study of the slender sugar cane types common in India. The general method of studying these cane plants suggests ways of becoming better acquainted with the crop we are producing. It is published here in the interest of what it may contribute to the work of improvement of cane by bud selection. While the Indian cane may differ from the varieties in Hawaii, this difference is largely one of degree.

The present research dates back to observations made in 1913, which showed that, in certain Punjab sugar cane varieties, there were differences in the canes growing in the same clump. These were found to be early and late in origin, the former being thin and long, with short joints at the base, and the latter thicker and shorter and commencing with much longer joints. A certain number of dissections had been made of the underground, branching portion of cane seedlings and wild Saccharums, and it was decided to commence a systematic study of this part of the cane plant in the field, in order clearly to demonstrate the true relations of the differing canes in each clump. As additional points of interest, referred to below, presented themselves, the series was greatly extended, and during the past two years a very large number of cane stools have been carefully studied.

For a proper understanding of the branching system of any plant, it is necessary to follow it from its earliest stages, and a study has accordingly been made of the germination of the sugar cane seed and the sprouting of planted sets.

The important question of tillering soon connected itself with the dissection work, it being well known that, not only do the thick canes differ considerably in this respect among themselves, but, as a whole, they tiller much less freely than the indigenous Indian canes. Unfortunately there appear to be few accurate observations published on the tillering of Indian canes, and our own notes are far from complete. It is, however, hoped that the facts here presented will give a stimulus to this important side of crop investigation. Even in the tropical sugar cane countries, although a vast number of observations have from time to time been made, there are few papers dealing with the subject from a scientific point of view, and the great bulk of the notes made are not available for our purpose. Spacing, which has given rise to so many experiments in such crops as wheat and paddy, appears to have been occasionally tried in sugar cane; but the results are not easily obtainable, and no help can be got from those crops which are grown for the production of grain. A summary has been prepared of the literature of this part of the subject.

* From Memoirs of the Department of Agriculture in India, Vol. X, No. 2 (abridged).



Branches of different orders in the dissection of *Saccharum arundinaceum*. The main stem, *a*, is in the center, and *b*s, *c*s, *d*s, *e*s, and *f*s are arranged on each side, passing outwards from the middle.

Attention was soon arrested by the fact, stated by various observers, that, during the lifetime of a cane plant, a great many deaths occur, so that the number of shoots in early stages greatly exceeds that found at crop time. These observations have been made entirely with thick canes, and doubts arose in our mind as to whether they were equally applicable to Indian canes, as the deaths were by no means obvious in the plots. A series of shoot countings once a month was accordingly instituted to throw light on the question, but the results of these are not yet available for publication.

Incidentally, in the course of dissection, it was observed that different cane varieties showed considerable differences in their mode and degree of branching; and not only was this the case with individual varieties, but whole groups could without difficulty be distinguished from one another in this respect. The degree of branching in the Indian canes was seen, as a whole, to differ very considerably from that in thick canes, and this led to a study of that of wild Saccharums, when it was found, as expected, that the Indian canes stood half way between the wild species and the thick canes of the tropics. A further stimulus was thus added to the work, and it was attempted to discover, in the branching of the cane varieties, a means of tracing the origin of the cultivated canes from their wild ancestors, and, among the Indian canes, to select such as might be considered the more primitive, and thus establish a connected series from the wild grasses to the thick canes of the tropics.

Lastly, differences were observed in the richness of the juice in the early and late canes of a plant, and these did not altogether tally with the views held regarding the richness of the thick and thin canes in tropical cane fields. The literature of the subject is punctuated by references to the relative richness in the juice of the "mother" cane and its branches, but, as no dissections seem to have been made, it is difficult to understand how the various observers distinguished these two classes of canes. There is obviously great confusion on the subject, for one observer. after stating his opinion, admitted that the mother shoot need not of necessaity be the original main shoot of the clump, but was the "thickest and best grown"! As will be seen, the result of our study is exactly the reverse, in that the main shoot is thinner and less well grown than its branches. This is indeed perfectly natural, when we consider the available equipment of leaves and roots in the young cane, as compared with that at the disposal of branches formed when the plant has grown up.

The dissection of the cane stool is a rather intricate and laborious piece of work. Upon taking it out of the ground, each clump is seen to be covered by a dense mass of tough roots, among which the soft buds are hidden, and these roots all have to be carefully cut away before the nature of the branching can be seen. The planting material with us consists of sets or pieces of cane on which there are at least three healthy buds, and these buds, usually all of them, develop into larger or smaller plants, which, however, are quite separate and only influence one another as regards the space available for their independent growth. It is usually impossible to make the dissection unless these plants are cut out and dealt with separately.

The main dissecting work was done in the 1916–17 and 1917–18 seasons, and in each year clumps were examined at two stages of growth for entirely

different reasons. The first was at about four months, for the determination of the rate of cane formation; and the second at about eight months, for the study of the canes formed at crop time. It was soon found that, after this latter date, no new canes could be started in time to mature. In 1916–17 the dissections were largely concentrated on the Saretha and Sunnabile groups, which at that time had recently been separated and were being described. Six varieties of each of these groups were examined, and to them were added a few from the other groups and some thick canes and wild Saccharums. Altogether 51 clumps, containing 133 plants, were dissected during this season. The results of this work were so suggestive and interesting that a fuller series was projected for the 1917-18 season. Six varieties of each of the five classes of Indian canes were chosen; to these were added six from the unclassified list, six thick cane varieties, the four wild Saccharums growing on the farm and six Madras seedlings, all of which were grown from sets. Owing to the poor growth of the thick canes, a further set of 24 stools was examined at the sugar cane plantation at Nellikuppam, these being all of the Red Mauritius variety, which was known to grow very well there under crop conditions. During this season 239 clumps, consisting of 629 plants, were dissected. The facts observed during the previous year were utilized for the preparation of a definite scheme of observations and measurements, the main purpose of which was the comparison of the branching systems of the different groups and the characters of the branches of different orders. In each plant dissected a diagram was prepared, in which the relative position of the branches was shown, and a formula was prepared, in algebraical form, of the constitution of the plant as far as matured canes were concerned. Besides this, all the canes were measured as to thickness and length of joints, and notes on runners, curvatures, injuries, etc., were recorded. The present paper seeks to extract the general principles of the branching of the sugar cane plant from this mass of material.

The following are briefly the results of this study. From the four months' dissections it is seen that the different varieties vary greatly in the rate of maturing and cane-formations, but this study is complicated by the fact that it was impossible to examine all the stools at the same time, owing to the large number dissected, the time occupied in the work extending over six weeks. A series of tables has been prepared, from which it is not difficult to judge of the relative rate of maturing of the different varieties.

From the general formulae of canes at harvest, obtained by averaging the dissections of all the plants of a variety, it is seen that the branching in the various groups, from the wild Saccharums to the thick tropical canes, is of the same nature, but of very different degree. Taking a to represent the main shoot, b its branches, c branches of b, that is of the second order, and so on, we get a series of formulae of the canes at crop time, varying from a—mb—c in the thick canes, to a—mb—nc—nd—me—f in the wild Saccharums, and the different groups of Indian canes can be arranged in a series between these two extremes. It is hoped that a study of these formulae will throw some light on the stage of development of each group from its supposed wild ancestor.

The differences in form and size between the branches of different orders in the same plant have been carefully studied. Each cane has been measured

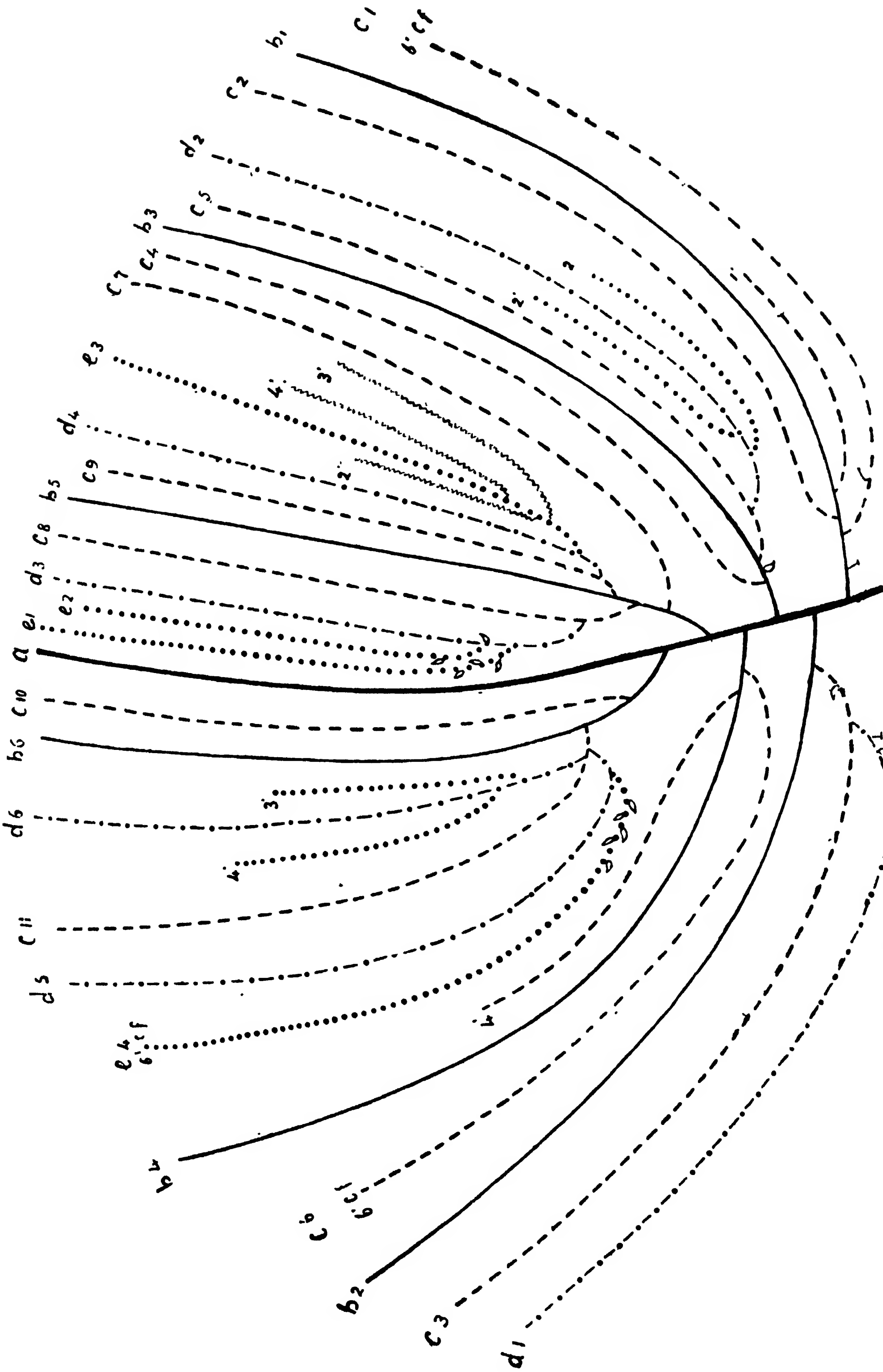


Diagram of the branching system in a plant of *Saccharum arundinaceum*.

as to the length of the basal, branching portion before it has assumed its full thickness, the thickness at two feet from the base, the average length of the joints in these two feet, the presence of curvature and runners, and so on. In all of these characters we find, as might have been expected, that there is a tardier development in the first shoot, and that this development increases in rapidity as the branches of the higher orders are reached. The general trend is for the branches of higher orders to be thicker, to have longer joints, and to show greater curvature. The main shoot has a longer basal, preparatory portion than its branches, but, when we pass to the other orders, the presence of basal curvatures, needed to place them in a position for upright growth, again increases the region of short joints at the base, for it is the general rule that a branch does not assume its full form until it is in a position to grow onward unimpeded.

The characters of the branches of different orders are seen to be so definite that, when a field is cut, we can without difficulty separate the canes at the mill into early and late. There is a good deal of similarity sometimes between the *a*s and *b*s, especially when the latter become facultative *a*s, but the change from *b*s to *c*s and *d*s is sufficiently striking to render their distinction generally very easy. This opens up a new line of work, in that it becomes possible to analyze these branches separately and to settle the question of their relative richness of juice and other qualities at the mill. Most of the work has, it is true, been conducted with Indian canes, and in one particular locality, but it seems unlikely that the thick canes will not fall into line, considering the general similarity of their branching system to that of Indian ones.

Forage Crops.

J. H. Midkiff makes the following observations in regard to experimental plantings of fodder crops for dairy feeding:

"At Lihue Plantation the elephant grass is growing much faster and looking healthier than the Uba cane or any of the sorghums. In a given time the elephant grass is probably producing three or four times as much feed as the Uba cane, and, contrary to expectations, it seems to be standing drought and sea breezes better than the Uba cane. The wild cow pea is not doing well here.

"At Grove Farm pigeon peas are doing fairly well with absolutely no attention. They were drilled into the soil. Since then they have received no fertilizer, irrigation, or cultivation of any kind.

"Mr. Krauss' best variety, the New Era Heavy Bearing, Early Maturing Pigeon Pea, is showing better results than the ordinary variety. The peas have been pastured since they were about two feet high. But until they began to produce seeds the cattle did not learn to eat them to any great extent."

[J. A. V.]

Rat Control Measures.

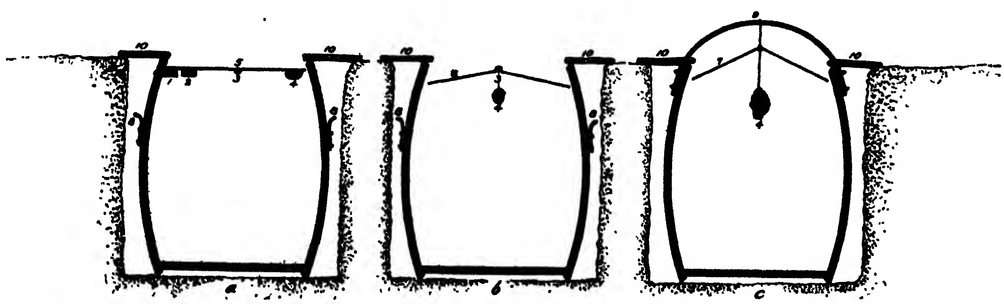
In a recent number of the Literary Digest, reference is made to the system of rat control which was described in the March number of the Record. The article which we published was taken from an English paper.

The recent comment by the Literary Digest on the same idea of control reads:

> The typical nine lives of the cat are apparently surpassed by her enemy the rat. Efforts to exterminate the rat as a plague-carrier have resulted only in increasing its reproduction rate and swelling its numbers, according to Dr. A. K. Chalmers, medical officer to the port of Glasgow. Says the British Medical Journal (London), reporting a meeting of the [British] Association of Port Sanitary Authorities, at which the doctor spoke:
>
> "Dr. Chalmers pointed out that though plague was primarily a disease of rats, there was no evidence that the rat plague in Eastern countries had diminished the number of rats; millions of rats had died of it in India, but there were as many there today as twenty years ago; not only were they numerically as strong, but from a bacteriological point of view their position was even stronger, since they might suffer from a chronic, non-fatal, but transmissible form of the disease. Again, at Copenhagen, when the authorities set out to trap and kill rats, the average catch was about 300,000; it was rapidly reduced by half, but remained at 150,000 for some time. It appeared that as fast as rats were killed the birth-rate rose; it was only by the adoption of a special policy which consisted in killing the females and liberating the males, who fought and exterminated each other, that the catch was reduced to 90,000. The general opinion of the meeting seemed to be that though it was possible to diminish the number of rats on ships it was impossible to exterminate them in the ports."

Any attempt to control rats by releasing the males after having disposed of the females, calls first of all for an effective system of trapping rats alive. A recent report by E. L. Caum pertains to this point:

"In response to your request for a memorandum on methods of trapping rats alive, I would say that I have seen the barrel method in operation



in Pennsylvania, and it seems to me that it ought to work pretty well in the cane fields, especially since the plan would be to kill only the females and release the males. The scheme is very simple, consisting merely of a barrel with a hinged top, the whole sunk in the ground so that the top is flush with the surface.

"The method of manufacture is as follows: (Fig. *a)* a large barrel is taken, preferably one with the sides as bulged as possible. A shallow groove

is cut in each side at the top deep enough to hold a small rod. The head of the barrel (5), which should be in one piece, is then balanced on a slender rod (3) and held in place with staples, so that it will turn freely. Then, when the ends of the rod, which project beyond the barrel top, are laid in the grooves which have been cut to receive them, we have a deep, concave-sided cage with a lid so nicely balanced that a very slight weight will cause it to tip. Now, fasten a light weight (2) to one side of this lid, on the under side, or suspend it from the lid by a short wire, and nail a small bit of wood (1) to the inside of the barrel near the top, and on the same side as the weight. This weight and stop serve to hold the lid horizontal. Needless to say, the weight should be heavy enough to tip the lid, or to bring it back when tipped, and no heavier. It would be well to smooth the top of the lid, to make the footing more precarious.

"The bait (4) is fastened to the side of the lid opposite the weight. When the rat goes after the bait, his weight overbalances the counterweight, thus tipping the lid and depositing him in the barrel. The counterweight then brings the lid back to the horizontal, closing the trap and at the same time setting it for the next victim.

"I have seen these traps in operation near barns, where rats were plentiful, and as many as fifty or sixty were caught in one barrel in a night. Of course, that was at the beginning. The catch fell off rapidly, as the available supply of rats diminished. In these places the animals were all killed, so the barrel was set solid in the ground, and kept half full of water.

"Where the object is to keep the animals alive until the sexes are separated, the hole should be dug enough larger than the barrel to accommodate a couple of handles (8), the space around the top being bridged by a wooden frame (10). A hole three and a half or four inches in diameter should be cut in one side of the barrel, at the bottom, and closed with a plug. Then, when the trap is taken up, this plug could be removed and the animals forced into a screen cage of some sort, where the females could be segregated and killed.

"Variations of this plan are shown in figures *b* and *c*. In fig. *b* the lid is made of a disc of zinc (6), bent across the rod (3), with the bait (4) suspended from this rod. This type of lid, while a trifle more difficult to make, dispenses with the stop and counterweight, and has the added advantage of tipping from either side. The shape of the lid tends to return it to the proper position after the animal has tipped it.

"In fig. *c*, the lid (7) consists of a shallow cone of zinc, suspended by the apex from a wire frame (9). In this case the bait (4) is hung directly below the apex. This type of lid has the advantage of tipping from any side, instead of from two, as in type *b*, or from only one, as in type *a*.

"Type *a* has the advantage of being simplest in construction, as it can be made entirely from material to be found around any plantation camp. Types *b* and *c* both call for a zinc disc, which must be bent across the middle in one case and made into a shallow cone in the other.

"These types are all effective—I can vouch for type *a*, and Mr. Potter tells me that he has seen both *b* and *c* in action. I might suggest that the best bait to use is something aromatic—a piece of fat bacon, for instance."

Hints on baiting rat traps are also supplied by the Literary Digest. From the issue of September 3, we read:

> A correspondent of the Daily Mail (London) is quoted in our issue of June 18 as asking, "Why are rats so keen on aniseed and rhodium?" The editor of the Mail understands this to mean the metal rhodium, and indulges in some pleasantry on the subject. Several correspondents, learned in pharmacy, write us to say that "oil of rhodium" has nothing to do with the rare metal of that name. Mr. Edward P. Higby, of the California State Hospital, Stockton, Cal., writes:
>
> "For the information of 'an ex-president of the Electro-chemical Society' and whoever else is only acquainted with rhodium as an element, I quote from the United States Dispensatory:
>
> " '*Oil of Rhodium*—This is said to be the oil from the wood of *Convolvulus scoparius* or *Genista canariensis*. It is used to adulterate oil of rose. *An oil of rhodium is sold to rat-catchers as a lure for rats*, which is made by mixing one part oil of rose with twenty parts oil of copaiba.' "
>
> A. R. Eberle, of Milwaukee, Wis., writes:
>
> "As a druggist, I will say that in regard to rhodium the London writer evidently wrote *oil* of rhodium. This is also used in bait to attract fish, and I feel certain is what the London writer had written."

The Rat Menace in India.[1]

Experiments have been conducted by Major J. C. G. Kunhardt and Assistant Surgeon G. D. Chitre on the eradication of plague infection by rat destruction. The observations made strongly support the view that the reduction in the rat population, resulting from plague itself (which attacks rats), is the main factor in bringing infection to a natural end, and that it yet remains to be seen if the destruction of rats by any artificial means is capable of producing or accelerating the same result.

A number of rat poisons was tested, but none was found better than barium carbonate, of which three grains is a fatal dose for the rat. It is best made into a bait with dough of some grain flour (the best grain was found to be bajri, *Pennisetum typhoideum* [2]), and without any addition in the form of fat, sugar, condiments, etc. (Indian Journ. Med. Research, Vol. VIII, No. 3, 1921, pp. 409, 446).

[1] From Nature, August 11, 1921.

[2] *Pennisetum americanum* Schum. (synonym, *P. typhoideum* Rich.), pearl millet. Occasionally grown in the southern states, where it ripens seed. A luxuriant annual, long cultivated in the Old World for forage and more or less for the grain, which is used as food.—Bailey, Standard Cyclopedia of Horticulture.

Preliminary Studies on Some Fungi and Bacteria Responsible for the Deterioration of South African Sugars.[1]

By PAUL A. VAN DER BIJL.

The author states that little attention has been given in South Africa to the nature and causes of the deterioration of stored sugars, a phase of research which will demand more and more attention with the increase in export. The study herein reprinted is of a preliminary nature, consisting in the main of results of experiments.

The fungi are now recognized as the most important of the micro-organisms resposible for the deterioration of stored sugar. In this paper four fungi and three bacteria are discussed, all isolated from samples of so-alled "sweating" sugar. The subject matter of the paper is divided into three parts: I. Fungi or Molds; II. Bacteria; III. General Considerations.

In the manufacture of commercial sugar in Hawaii we have largely solved our problem of deterioration through mill sanitation and the reduction of the moisture content in our sugars.

PART I—FUNGI OR MOLDS.

(a) Preliminary Test.

As a preliminary test, the fungi isolated from sugar samples were first tested to see if they contained the enzyme invertase which inverts cane-sugar, and only those which gave decidedly positive results were retained for further study.

To test for invertase the fungoid growths from artificial media were first well washed in water, then crushed with water in a mortar, and after the addition of toluene as a disinfectant left overnight for the enzyme to diffuse out. The following morning the mixtures were filtered, and the following series of experiments set up for each fungus:

Active Extract—20 c.c. 1 per cent sugar solution + 5 c.c. unboiled filtrate + 1 c.c. toluene.
Boiled Control—20 c.c. 1 per cent sugar solution + 5 c.c. boiled filtrate + 1 c.c. toluene.

The flasks containing these mixtures were incubated at 30° C. for twenty-four hours, when the mixtures were tested for reducing sugars with Fehlings solution in the usual way. If any invertase was present in the fungoid extracts then the active extract should show an inversion of the cane-sugar. In the boiled control the enzyme had been destroyed by the heating, and there should hence be no inversion, or, at most, only a slight one, probably from the sugar used. The toluene was, of course, added as a disinfectant to prevent the growth of micro-organisms in the mixtures.

The premliminary test gave a rough idea of the economic importance of the fungi isolated from sugar samples, and for this investigation four of them

[1] Department of Agriculture, Union of South Africa, Science Bulletin No. 12. 1920.

were kept for further study, though I must say that these are not the only ones, and before we have finished with the investigation we will probably have quite a number more.

(b) The Fungi.

An opportunity for studying fully the morphology of the fungi has not yet offered itself, and I consider it advisable to deal with this aspect in a separate paper after more of them have been isolated and studied. For this reason I give only brief notes on the fungi with a few sketches to indicate their nature. They are:

Aspergillus sp.—This same fungus was obtained from sugar at different times, and two isolations of it were utilized in almost all of the experiments.

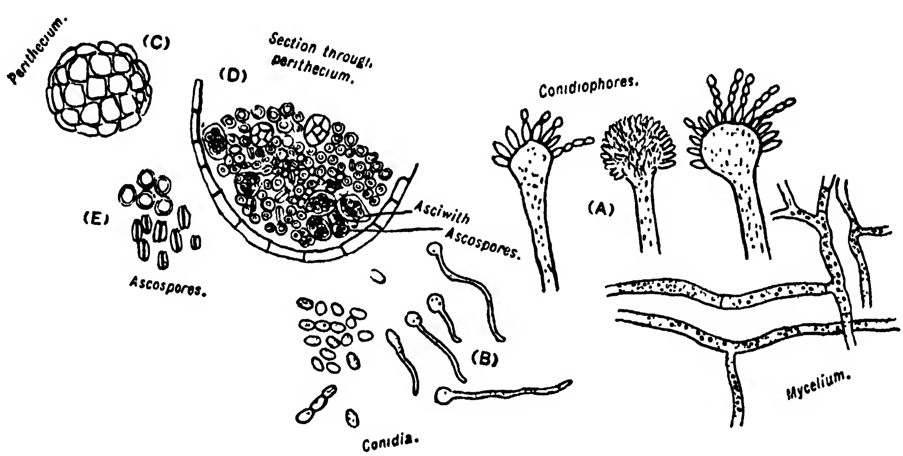


Figure 1. *Aspergillus Fungus*—Life-History of the.

The fungus is illustrated in figure 1. The conidial herbage is greenish and at (a) are shown the swollen conidiophores which bear the finger-like processes from which the conidia are abstricted. At (b) are shown some conidia germinating. The conidia are globular to more or less elongated, with smooth or minutely punctuate walls, and measure 2.4 by 4.8 or 2.4–3.6 μ. This fungus very readily develops another fruiting body, which takes the form of a yellowish case, illustrated at (c), and in which on cutting it across we notice a number of sack-like structures (asci), each of which contains a number of spores (ascospores). Such a section is shown at (d), and at (e) are shown some of the ascospores. The ascospores are ellipsoidal, exhibit a longitudinal furrow, and measure 3.6-4.8 by 2.4-3 μ. Figure 2 shows the fungus growing in the laboratory on artificial media.

Stemphylium—This fungus offered considerable difficulty in placing it, and until such time as it has been further studied it is provisionally placed in the genus *Stemphylium*. The spores are brown in color, large, and divided by transverse walls into many cells. Some of these cells are again divided by a longitudinal septum. This fungus is illustrated in figure 3.

Sterigmatocystis—This genus is not sharply defined from the genus *Aspergillus* mentioned above. In *Aspergillus* the finger-like process arising from the

Figure 2. *Aspergillus Fungus*—Growth in Laboratory.

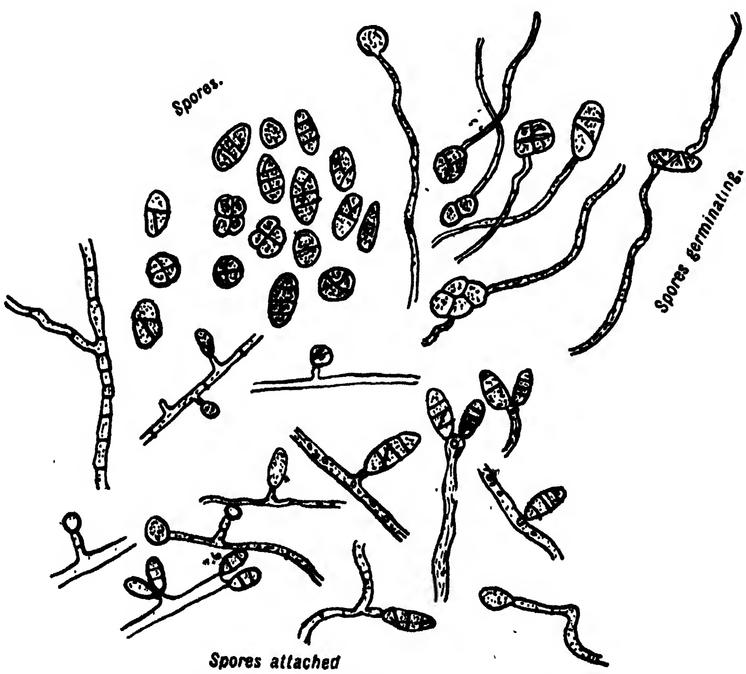


Figure 3. *Stemphylium Fungus*—Illustrations of the

swollen head bear the conidia directly, whereas in *Sterigmatocystis* they bear secondary finger-like processes, and these bear the conidia. The fact that simple and branched finger-like processes may occur in the same fungus is, however, unfavorable to such a distinction being made, and *Sterigmatocystis* is now usually merged in *Aspergillus*. I use the name *Sterigmatocystis* merely to distinguish this fungus from the previously mentioned *Aspergillus*. This fungus is illustrated in figure 4, and in figure 5 are shown the colonies of the fungus grown artificially in the laboratory.

The conidia of this fungus as seen from figure 4 are round, and their outer walls are rough, with minute projections. They are 2.4–3 μ in diameter. The conidial herbage is dark greyish green. To date this fungus has produced only conidial fructifications.

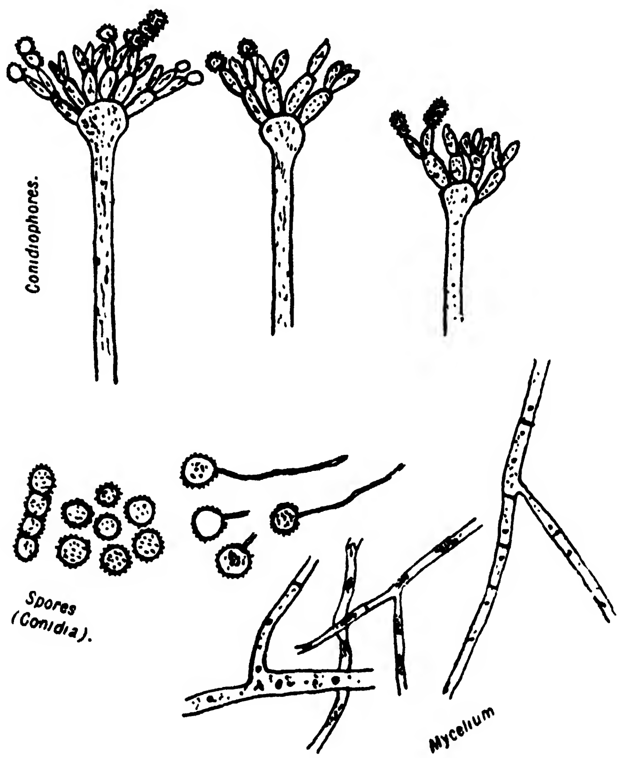


Figure 4. *Sterigmatocystis Fungus*—Illustrations of the.

These few remarks on the nature of the fungi are at present sufficient for our purpose, and I do not wish to overburden the paper with details of little interest to the sugar producer.

(c) Inoculation of Fungi into Liquid Media containing Sucrose.

After the preliminary test for invertase the fungi were grown in media containing sucrose, and these tested to find whether the fungi had inverted the sucrose. The results of analysis are given in Tables I to III.

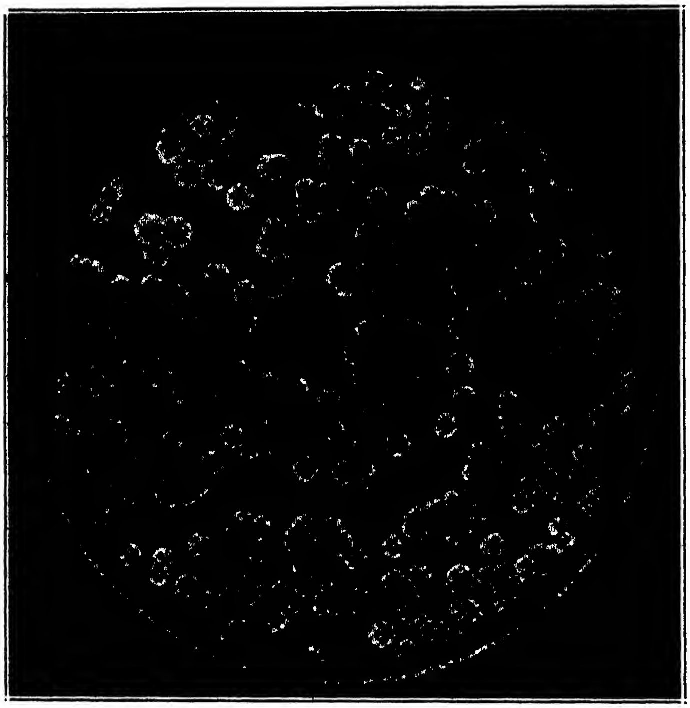


Figure 5. *Sterigmatocystis Fungus*—Growth in Laboratory.

TABLE I.—DOX SOLUTION:[1] RESULTS OF ANALYSIS FOUR DAYS AFTER INOCULATION.

Fungi.	Invert sugar in 100 c.c.
Aspergillus	1.5
Stemphylium	.47
Sterigmatocystis	1.3
Control	..

TABLE II.—DOX SOLUTION.—RESULTS OF ANALYSIS FOUR DAYS AFTER INOCULATION.

Fungi.	c.c. $\frac{N}{20}$ Caustic Soda to neutralize 20 c.c.	Invert sugar in 100 c.c.
Aspergillus	13.2	.53
Stemphylium	10	.76
Sterigmatocystis	11.8	.8
Aspergillus (*a*)	18	1.8
Control	11	Trace

[1] Sodium nitrate 1, potassium nitrate 1, potassium phosphate .5, magnesium sulphate .01, potassium chloride .01, ferrous sulphate .01, ~~sugar 30~~, water 1000.

TABLE III.—20° BRIX MILL SUGAR SOLUTION (CLARIFIED WITH ALUMINA CREAM): ANALYSIS FIVE DAYS AFTER INOCULATION.

Fungi.	c.c. $\frac{N}{20}$ Caustic Soda to neutralize 20 c.c.	Invert sugar in 100 c.c.
Aspergillus	1.2	10
Stemphylium	.7	.357
Sterigmatocystis	1	1.26
Aspergillus (*a*)	1.3	15.15
Control	.4	.086

The series of experiments recorded in Tables I–III then left no doubt as to the capability of the fungi to invert sucrose. Table III is remarkable for the high amount recorded under invert sugar for the *Aspergillus* fungus. It is unlikely that all is invert sugar, and most probably the high results are in part due to the presence of other reducing organic substances in addition to invert sugar. That such is probably the case is further indicated by instances where the amount of invert sugar produced was in excess of the cane-sugar started with. Other results of inoculations into mill sugar solutions gave similar high results, and such high results were also obtained with these two fungi when grown in Dunhams solution + sucrose. The difference obtained with the different media probably suggests that the form in which the nitrogenous food is presented may have something to do with it, but it is a matter which I have not yet gone into. Sucrose in solid form offers rather a peculiar medium for the growth of microorganisms, and in addition to the results recorded above it hence appeared desirable to infect some sugar as well.

(d) Infection of Sterilized Sugars.

For this purpose 20 gms. refined sugar were sterilized in previously sterilized flasks. The sugars were then inoculated with the fungi, and, after this, as near as possible the same amount of sterilized distilled water sprayed into each flask. A control flask containing the same quantity of sugar was treated in the same way, except that it was not inoculated. After squirting water on to the sugars, a piece of rubber tubing was tied over the top of the flasks (to prevent evaporation), and the flasks then incubated at 27° C. An analysis made twenty-two days after incubation is given in Table IV.

TABLE IV.

Fungi	Per cent. Moisture	Per cent. Invert Sugar
Aspergillus	2.13	1.3
Stemphylium	2	1.2
Sterigmatocystis	1.8	1.03
Aspergillus (*a*)	2.3	2
Control	1.7	.49

The above then left no doubt that the fungi had inverted the sucrose. To obtain conditions more in accordance with what would take place in storage we next weighed out 10 gms. sugar in previously sterilized flasks. These sugars were, after sterilization, infected with the fungi, but instead of squirting water into them they were covered with a bell-jar, under which was placed a small beaker containing a saturated solution of sugar, to which was added a crystal of mercuric chloride as a disinfectant. The sugars had now to absorb their moisture from their surroundings. The apparatus was incubated at 27° C., and at intervals the flasks were weighed to determine the amount of water absorbed. After twenty-one days the sugars were analysed. In Table V I give the results of this experiment.

TABLE V.

Fungi	Increase in weight in milligrams				Per cent. Invert Sugar after 21 days (on dry weight)
	4 days	7 days	10 days	14 days	
Aspergillus	39	An accident befell this flask in that water dropped on the cottonwool and the weighing of it was hence discontinued.			1.6
Stemphylium	40	110	170	210	1
Sterigmatocystis	57	144	215	277	1.3
Control	30	90	130	161	.73

Here the results again indicate that the fungi have inverted the cane-sugar. The fact that the inoculated sugars absorbed more water[1] than the control I take to be due to the greater hygroscopicity of invert sugar.

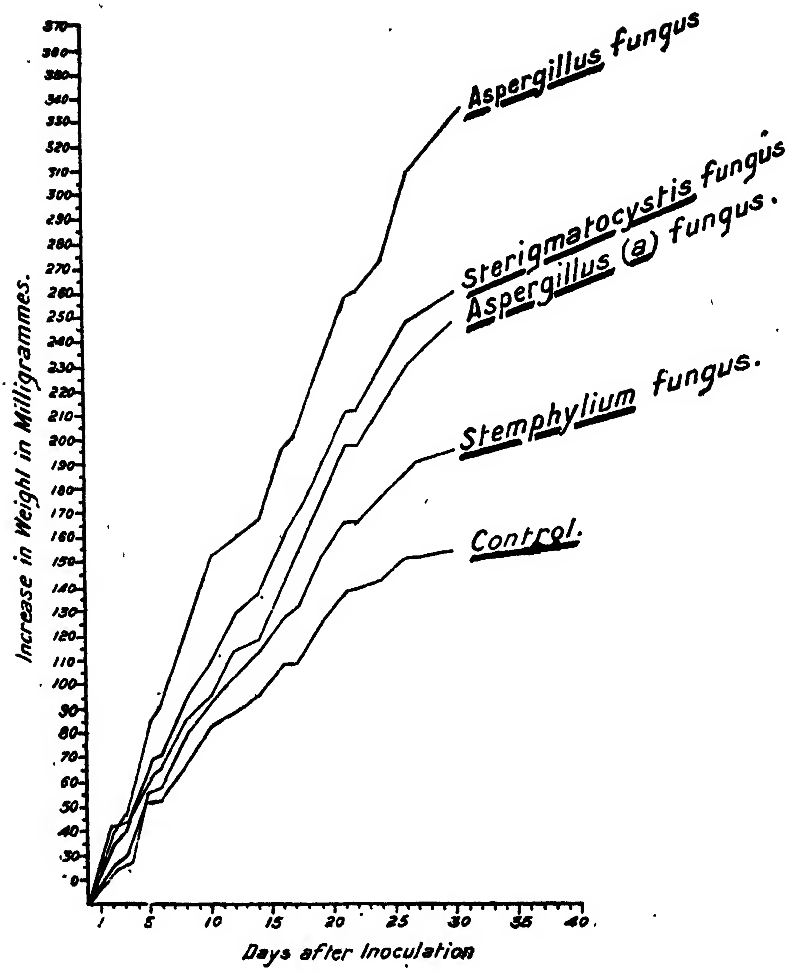
This experiment was repeated, and the results are expressed in Table VI; and in Table VII the increase in weighings is shown graphically:

[1] C. A. Browne (Pl. Rec. XVIII, p. 494-5) points out that a greater water content is present in infected sugars even in sealed containers, the additional moisture in this event apparently being a product of decomposition. W. R. McAllep states that we have data confirming this point.—(C. W. C.)

TABLE VI.

Day after inoculation..	2	3	5	6	8	10	12	14	16	17	19	21	22	24	26	27	30	Per cent. Invert Sugar 30 days after inoculation (dry weight)
	Increase in Weight in Milligramms																	—
Control..............	25	28	52	52	67	83	88	95	108	108	125	137	137	141	150	150	152	.215
Aspergillus	41	45	84	90	120	153	159	166	195	199	230	255	258	271	307	312	329	.97
Stemphylium	24	26	56	58	77	91	104	113	127	129	151	165	165	174	186	189	194	.668
Sterigmatocystis	34	38	68	71	93	108	128	137	159	166	188	211	211	228	245	249	258	.85
Aspergillus (a).........	42	42	62	65	85	95	113	118	141	148	173	196	196	210	227	232	246	.801

TABLE VII.



The last two experiments then show not only that the fungi invert sugar, but also that the infected sugars take up more moisture from their surroundings, and the fungi hence have some bearing on the process popularly called "sweating." To prevent any misunderstanding I would, however, mention at once that "sweating" may result without any micro-organisms being present, due it is held to adhering films of molasses and brought about by improper conditions of storage. The "sweating" of a sterile sugar would, however, not be accompanied by deterioration such as we record.

(e) Growth in Sugar Solutions of Different Densities.

Sugar in solid form appears a peculiar medium to micro-organisms. We would, for example, expect micro-organisms living on it to be capable of withstanding high concentrations of the medium, and the natural medium being poor in albuminoids we would expect the germs living on it to have low nutritive requirements. The second requirement necessary to these germs we have seen fulfilled by the inoculation of sterilized sugars. To test the concentrations of

sugar in which the fungi are capable of growing mill sugar solutions of different degrees Brix were prepared. The solutions were tubed, and after sterilization inoculated with the fungi and incubated.

With the exception of *Stemphylium* all the fungi grew in solutions of 63° Brix concentrations. *Stemphylium* grew in concentrations of 58.7° Brix, but not in 63° Brix, the highest concentration tested.

(f) Resistance of the Fungi to Heat.

None of the fungi are very resistant to heat, as was shown by placing tubes of sugar solutions inoculated with them in boiling water for different periods. Fifteen minutes' (the shortest period tested) immersion was sufficient to kill them all.

They would hence not withstand the temperatures met with in sugar factories, and the results would further suggest that for them steam would be both a cheap and an efficient method of disinfection.

Though the fungi easily succumb to the temperature of boiling water their economic importance is in no way diminished, as infection may take place afresh at different stages in the manufacture of sugar, depending, of course, on the sources of infection and the liability of the particular sugar to deterioration.

(g) Tests Against Various Disinfectants.

The fungi were tested against various disinfectants, and we selected for our experiments those which are used, or have been recommended, either in the sugar or allied industries. Those tested were: Formalin, chloride of lime, bisulphite of soda, lime-water, sodium fluoride. The details and results are given under each.

Flourides.

Hydroflouric acid and certain of its salts have a powerful germicidal action. A 5 per cent solution of ammonium flouride is recommended by Jorgensen for cleaning vats in distilleries and breweries. It has also been recommended in the beet sugar industry as an excellent means of combating *Leuconostoc mesenteroides.* Harloff recommends a 1 per cent solution of sodium flouride as a sugar factory germicide, and especially for cleaning the rollers as well as for general germicidal purposes.

We tested our fungi against sodium flouride and ammonium flouride as follows: To 50 c.c. of mill sugar solution in small flasks were added the quantities stated in the tables below. The flasks were then sterilized, and after sterilization inoculated with the fungi and incubated.

The results are given in Tables VIII–IX, where

+ = growth
— = no growth.

TABLE VIII.—GRAPHICAL REPRESENTATION OF THE INCREASE IN MOISTURE ABSORPTION IN SUGARS INFECTED WITH THE FUNGI.

TABLE VIII.—SODIUM FLUORIDE.

Fungi	Grammes added to 50 c.c. mill sugar solution				
	.1	.2	.25	.27	.3
Aspergillus	+	—	—	—	—
Stemphylium	+	—	—	—	—
Sterigmatocystis	+	+	+	—	—
Aspergillus (a)	+	—	—	—	—

TABLE IX.—AMMONIUM FLOURIDE.

Fungi	Grammes added to 50 c.c. mill sugar solution					
	.1	.2	.25	.3	.5	1
Aspergillus	+	+	....	+	—	—
Stemphylium	+	....	+	—	—	—
Sterigmatocystis	+	+	+	+	—	—
Aspergillus (a)	+	+	+	+	—	—

Bisulphites.

Jorgensen recommends both sodium bisulphite and calcium bisulphite for use in breweries and distilleries, and both these substances have also been recommended as germicides for sugar factories.

We experimented with sodium bisulphite as follows: 50 c.c. mill sugar solution were sterilized in flasks, and after sterilization different quantities of a 5 per cent solution of sodium bisulphite added. The flasks were then inoculated and incubated, and the results are given in Table X, where:

+ = growth

— = no growth.

TABLE X.—BISULPHITE OF SODA.

Fungi	c.c. 5 per cent. Sodium Bisulphite added to 50 c.c. mill sugar solution					
	.2	.5	1	1.5	2	4
Aspergillus	+	—	—	—	—	—
Stemphylium	+	+	+	+	+	—
Sterigmatocystis	+	+	—	—	—	—
Aspergillus (a)	+	—	—	—	—	—

Formalin.

Jorgensen recommends the use of formaldehyde in 5 per cent strengths for cleaning vats in breweries and distilleries.

In the beet sugar industry it has been recommended to prevent fermentation in the diffusion batteries. In the sugar industry as a whole formalin is

generally employed for the preservation of laboratory samples, and Spencer recommends for this purpose 3 c.c. of formalin to a cubic foot of juice clarified by the sulphur process, and 6–8 c.c. to a cubic foot of juice clarified by the ordinary process.

Simpson, in 1908, advocated the addition of formalin solution to all juice from the cane, and claimed that, in addition to destroying organisms which cause deterioration, it aided in the purification by eliminating albumins and pectins. He recommended a 2 per cent water solution of formaldehyde to the raw juice at the first mill, in the proportion of one part of the solution to 1000 parts of juice. This is approximately equivalent to 1 part of 40 per cent commercial formalin to 20,000 parts of juice.

To my knowledge the above suggestion of Simpson has not found acceptance, and I can find no reference stating that formalin is employed, as he suggested.

Owen concludes that formaldehyde is superior to any germicide for disinfecting syrup tanks or removing micro-organisms, which cause deterioration of sugar.

Norris reported on changes in the polarization of sugar solutions brought about by the addition of formalin, and he holds that an unstable compound is formed between these two substances, and that this has a higher polarization than sugar itself. He further shows that in the proportion of 1 part or less of formalin to 100 of mill juice the polarization is not affected, and that concentrated sugar solutions have their polarizations raised by smaller quantities of formalin than weaker solutions. Upon diluting such concentrated solutions the increase in polarization disappears.

Numerous experimenters with different fungi and bacteria record that 1:10,000 to 1:20,000 of formaldehyde generally suffices to render the organisms sterile, but that it takes at least 1:1000 to kill them.

For testing formalin on our fungi, various quantities of a .5 per cent solution of commercial formalin was added to 50 c.c. of sterilized mill sugar solution, and the mixtures then inoculated with the fungi and incubated. The results are given in Table XI, where "+" indicates growth and "—" no growth.

TABLE XI.—FORMALIN.

Fungi	c.c. of .5 per cent. solution of commercial Formalin added to 50 c.c. of mill sugar solution							
	2	4	5	7	8	9	10	12
Aspergillus	+	+	+	+	+	+	+	—
Stemphylium	+	+	+	+	+	—	—	—
Sterigmatocystis	+	+	+	+	—	—	—	—

The above table is based on observations taken at intervals for seven days. It is probable that during this period a certain amount of the formalin may have evaporated, and the fungi not having been killed, but only retarded, continued their growth. Also, as every sugar chemist knows, a certain quantity of the disinfectant may inhibit the growth of germs in his juices for a certain period

only, and if he wishes to preserve his juices for a longer period he has to add a larger quantity of the disinfectant. It was noted that 4.5 c.c. of the formalin solution inhibited the growth of all the fungi for two days. This works out roughly to 1 pint of commercial formalin solution in 2300.

Chloride of Lime (Bleaching Powder).

This substance has been recommended in breweries for the disinfection of filter-bags, and finds a similar use in sugar factories.

Owen concluded that in cases where the germicide involved any great penetrating power, as, for example, where gums are to be removed, and in cleaning tanks which contained fermented juices, this substance is more economical than formalin. Will, who experimented with material obtained from a brewery, recommends a solution containing 1 per cent available chlorine.

In our experiments below, 2 grammes of the chloride of lime were dissolved in 100 c.c. water, well shaken, and the sediment allowed to settle. Varying quantities of the supernatant liquid were then added to 50 c.c. mill sugar solution in flasks; the flasks infected with the fungi were incubated.

As the amount of available chlorine varies considerably in different samples, it was thought desirable to determine it for the material used, and it was found to contain only 16 per cent of available chlorine, which is very low.

In Table XII below are given the results with chloride of lime:

+ = growth
— = no growth.

TABLE XII.—CHLORIDE OF LIME.

Fungi	c.c. of 2 per cent. Chloride of Lime, having 16 per cent. available Chlorine, added to 50 c.c. sterilized mill sugar solution								
	.2	.5	1	1.5	2	3	4	5	6
Aspergillus	+	+	+	+	+	+	+	+	—
Stemphylium	+	+	+	+	+	+	—	—	—
Sterigmatocystis ..	+	+	+	+	—	—	—	—	—
Aspergillus (a)....	+	+	+	+	+	+	+	—	—

In the sugar solution, to which 6 c.c. of the chloride of lime were added and in which none of the fungi grew, there was approximately .03 per cent of available chlorine.

Milk of Lime.

Jorgensen recommends fresh milk of lime as a disinfectant for the walls and ceilings of breweries and distilleries. It is employed in the sugar industry for cleaning the rollers and for general germicidal purposes. As is well known this substance is inefficient in preventing the growth of *Leuconostoc mesenteroides,* which growth is at times so bad in factories as to cause the blocking up of the pipes. This inefficiency may possibly be due to the fact that this organism favors a neutral or slightly alkaline solution.

Quicklime, being always on hand in sugar factories, makes milk of lime a

particularly suitable factory germicide, and Owen recommends it as more economical than formalin for cleaning vats containing fermented juices. We used a milk of lime solution containing 5 per cent CaO and noted that even when 5 c.c. of this solution was added to 50 c.c. of sugar solution there was no growth. Allowing the sediment to settle and using only the clear supernatant fluid, even the addition of 20 c.c. to 50 c.c. of mill sugar solution did not prevent the growth of these fungi. We believe the difference is in large part probably due to the fact that in using milk of lime the fungus is carried to the bottom with the lime particles as these subside.

An Additional Fungus.

While the work on the fungi reported was nearing completion, another was obtained, and it was thought desirable to just embody the few results about it in this paper. This fungus is *Hormodendron cladosporoides.* The spores are colored and their method of formation is illustrated in figure 6.

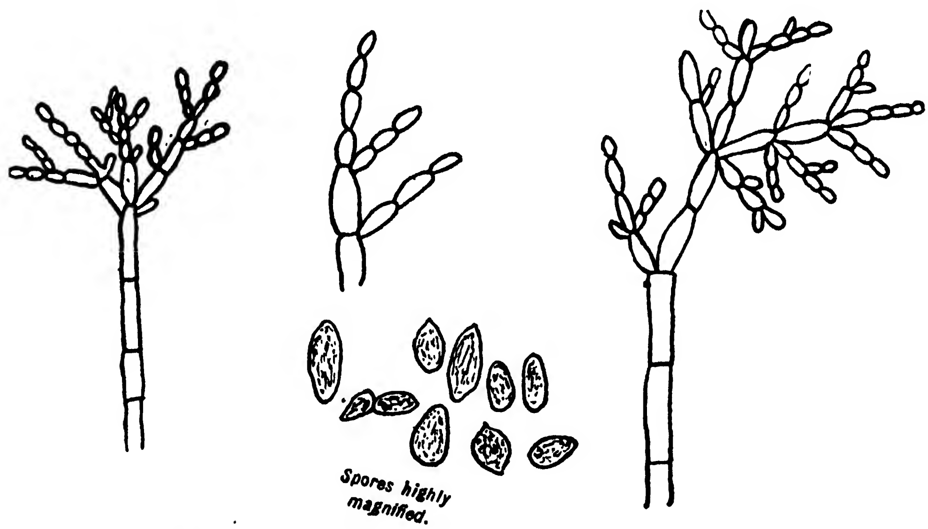


Figure 6. *Hormodendron Fungus*—Illustrations of the.

Action on Media Containing Sucrose.

TABLE XIII.—DOX'S SOLUTIONS, FOUR AND ELEVEN DAYS AFTER INOCULATION.

	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control..............................	8.7	.09
Inoculated .... I } —4 days	{12.3	.14
" ....II } —4 days...........	}10.4	.46
" ...III —11 days..........	15	1.7

TABLE XIV.—MILL SUGAR SOLUTION, FOUR DAYS AFTER INOCULATION.

	c.c. Caustic Soda — $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control..............................	1.5	.25
Inoculated..... I........................	1.2	.78
" .... II........................	1.15	.9

Part II—Bacteria.

I believe Dobson (1902) was the first who investigated bacteria in connection with the deterioration of sugars. His publication, "Relation of Bacteria to the Inversion of Crystallized Sugars," was not available to me. At about the same time as Shorey published on the fungus *Penicillum glaucum,* Greig Smith published an article entitled "The Deterioration of Raw and Refined Sugar Crystals in Bulk." In this article he attributed the deterioration to a bacterial organism which he named *Bacillus levaniformis.* The second name refers to the property of this bacillus for forming the gum levan from sugar. Greig Smith at the same time pointed out the similarity between his organism and the group of bacteria known as the "Potato Bacilli." In a few words the most striking features of this group can be given as:

(1) The high resistance of their spores to heat.
(2) Their capacity of forming gum in the fermentation of sugars.
(3) Their low nutritive requirements.

Lewton-Brain and Noel Deer deal with five gum-forming bacteria isolated from sugars. Owen, in extending the investigations on sugar bacteria, compared them with members of the potato group and also showed that members of this group isolated from sources other than sugar products can acquire the property of destroying sugar.

The three bacterial organisms from sugar which we have thus far worked on belong to the potato group of bacilli. That they are all three closely related is shown by their cultural, morphological, and physiological characters.[1]

* * * * * * *

Bacillus I and Bacillus II are nearest to *Bacillus vulgatus* and Bacillus III to *Bacillus gummosus.*

We have thus far not made any systematic survey of the micro-organisms occurring in the mills, but have incidentally obtained an organism belonging to the same group of bacteria from juice at the first roller.

Inoculation of Media containing Cane-sugar with the three Bacterial Organisms and Subsequent Determination of Invert Sugar in the Media.

(a) [2] Dunham's solution + 10 per cent sucrose. Analysis three days after infection is given in Table XVII.

[1] Tables XV and XVI of cultural, morphological, and biochemical featurs of the three bacteria are omitted.

[2] Peptone 1, Sodium Chloride .5, Sugar 10, Water 100.

TABLE XVII.

	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control	1.8	.06
Bacillus I	2.95	1.25
Bacillus I	3	1.5
Bacillus II	3.3	2.4
Bacillus III	3	1.7
Bacillus III	3.1	1.7

(b) Mill sugar solution 20° (Brix), three and seven days after inoculation.

TABLE XVIII.

	3 days after infection		7 days after infection	
	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control	1.5	.25	—	—
Bacillus I	1.35	1.7	1.8	3.3
Bacillsu II	1.6	2.6	1.7	3.7
Bacillus III	1.4	.33	1.7	.43

These experiments show the three bacterial organisms capable of inverting sucrose.

Formation of Gum.

They were next again grown in 20° Brix mill sugar solution, and this tested to find if there was an increase in ash-free alcoholic precipitate.

TABLE XIX.—ASH-FREE ALCOHOLIC PRECIPITATE PER 100 C.C., EIGHT DAYS AFTER INOCULATION.

	Ash-free Alcoholic Precipitate per 100 c.c.—8 days after inoculation.
Control	.03
Bacillus I	.72
Bacillus II	.17
Bacillus III	.08

The amount of ash-free alcohol precipitate formed by these bacterial organisms in 20° Brix raw mill sugar solution differed considerably in different experiments. Below I give the result obtained in an experiment, using the same sugar as was used above:

TABLE XX.—ASH-FREE ALCOHOLIC PRECIPITATE PER 100 C.C., TWELVE DAYS AFTER INOCULATION.

	Ash-free Alcoholic Precipitate per 100 c.c.—12 days after inoculation.
Control	.03
Bacillus I	.096
Bacillus II	.42
Bacillus III	.11

These experiments hence show that in addition to inverting sugar one of the products formed by these micro-organisms is gum.

Resistance of the Spores of the Bacteria to Heat.

The spores of bacteria are usually very resistant to heat, and we have noted that this applies specially to the potato group of bacilli.

To test their resistance to heat, tubes of sugar solution were infected from old cultures. These tubes were placed in boiling water, and at intervals plates were poured from them.

In Table XXI below I give the results obtained: + indicates that growth took place; — indicates that there was no growth, i.e. the spores were killed.

TABLE XXI.

Time of Exposure	15 Minutes	30 Minutes	1 Hour	2 Hours
Bacillus I	+	+	+	—
Bacillus II	+	+	+	—
Bacillus III	+	+	+	+

The spores of the bacteria are, as is evident from the table above, highly resistant, and survived the temperature of 100° C. (212° F.)—in cases even for as long as two hours.

Tests with Various Disinfectants.

The disinfectants tested were those mentioned when dealing with fungi.

We used a different method and proceeded as follows: To test their antiseptic property on the bacteria, i.e. the strength in which they prevented the growth of the bacteria, solutions of them were made up double the strength it was desired to test. When 5 c.c. of these solutions were added to 5 c.c. of sugar agar tubes, it gave the desired strength. The sugar agar was melted up and the disinfectants added just before setting. The tubes were well shaken and then slanted, and when the agar had solidified they were inoculated with the bacteria. To test the germicidal properties the 5 c.c. of the disinfectants of different strengths were added to 5 c.c. of sterilized mill sugar solution. Into these tubes were then pipetted .1 c.c. of a fresh culture. The inoculated tubes were then incubated at 30° C. for 30 minutes, after which time plates were poured from them in order to find whether the bacteria had been killed. The cultures used for testing the antiseptic and germicidal properties of the

different disinfectants were in every instance less than 24 hours old. The results obtained are given in the tables below.

+ indicates the strengths of the disinfectants found to be antiseptic or germicidal, respectively.

— indicates that in these strengths the disinfectants were not antiseptic or germicidal.

TABLE XXII.—FORMALIN—ANTISEPTIC PROPERTIES OF COMMERCIAL FORMALIN.

Strengths	1 : 10,000	1 : 5,000	1 : 2,500
Bacillus I....................	—	+	+
Bacillus II....................	+	+	+
Bacillus III....................	+	+	+

In the proportion of 1:5000 the commercial formalin is hence antiseptic to all the bacteria experimented with.

The germicidal properties of this substance were tested only against Bacillus I and II, and it was found that even 1:50 of commercial formalin did not kill these bacteria in the 30-minutes' exposure.

The use of formalin in mills is, however, primarily as an antiseptic.

TABLE XXIII.—SODIUM FLUORIDE—ANTISEPTIC PROPERTIES.

Strengths	.031 per cent.	.062 per cent.	.125 per cent.	.25 per cent.	.5 per cent.
Bacillus I..............	—	—	—	+	+
Bacillus II..............	—	—	—	+	+
Bacillus III..............	—	—	—	+	+

The germicidal properties of this substance were tested against Bacillus I and II, and it was found that a 30-minutes' exposure to a 1 per cent solution did not prove germicidal.

TABLE XXIV (A) AND (B).—BISULPHIDE OF SODA.

(a) Antiseptic Properties.

Strengths	.015 per cent.	.031 per cent.	.062 per cent.	.125 per cent.
Bacillus I..............	—	+	+	+
Bacillus II..............	—	—	+	+
Bacillus III..............	—	—	+	+

(b) Germicidal Properties.

Strengths	.125 per cent.	.25 per cent.	1 per cent.	2 per cent.	4 per cent.
Bacillus I..............	—	—	—	+	+
Bacillus II..............	—	—	—	+	+
Bacillus III..............	—	—	—	+	+

TABLE XXV.—CHLORIDE OF LIME—GERMICIDAL PROPERTIES.

Strengths.	.25 per cent.	1 per cent.	2 per cent.
Bacillus I	—	—	+
Bacillus II	—	—	+
Bacillus III	—	+	+

The chloride of lime experimented with contained 21.3 per cent available chlorine, so that in the 2 per cent solution tested there was approximately .4% of available chlorine.

PART III—GENERAL CONSIDERATIONS.

In the foregoing pages we have noted some of the organisms responsible for the deterioration of sugars and the nature of the changes which they induce.

We cannot dismiss the subject without drawing attention to some of the views of other investigators and noting certain factors which would influence the liability of deterioration of sugars by micro-organisms. Amongst these we mention

Moisture Content.

Moisture is essential to the growth of all micro-organisms. Lewton-Brain and Norris claim that no deterioration can take place in a sugar containing less than 1 per cent moisture. With this Owen agrees and points out that the validity of the "factor of safety" $\frac{\text{water}}{(100 - \text{pol.})} = .333$ decreases as we depart from a film of natural molasses around the crystals and deal with washed sugars, i.e. washing the sugar increases its purity and hence the ratio of $\frac{\text{moisture}}{\text{solids non-sucrose}}$ is increased, or in other words the density of the molasses film around the crystals is decreased, and the sugar becomes more liable to deterioration. Owen writes: "Evidently one of the surest means of manufacturing raw sugars which will not deteriorate in storage is to keep the density of the molasses films surrounding their crystals beyond 75 Brix. This applies, of course, only to raw sugars, as the keeping quality of white sugar must, in the nature of the case, depend upon its absolute dryness. But to manufacture sugars with a polarization of 96, with films of very low purity molasses necessitates a thorough purging of the crystals, so that they will retain only a small amount of molasses, otherwise the polarization of the sugar would be too low. However, a good purging can only result from good and effective clarification, and it is to the deficiency in this respect that much of the trouble from deterioration is due. If the massecuite is viscous from excess of lime it does not purge well and excessive amounts of water have to be used in the centrifugals."

This suggestion of Owen is, of course, based on the fact that in a molasses film of high density micro-organisms cannot grow. A sugar having the required "factor of safety" can, of course, become unsafe through the absorption of moisture from the atmosphere by which the ratio $\frac{\text{water}}{\text{solids non-sucrose}}$ would be

increased, or we may regard it as the film of molasses being diluted and the growth of micro-organisms made possible. For the same reason the factor of safety becomes less reliable in high-grade washed sugars as the molasses film is diluted, and in white sugars the total moisture present is the only criterion of safety, since the density of the film cannot be high enough to prevent the growth of micro-organisms. These considerations of Owen appear quite sound and plausible.

The next is the absorption of moisture by sugars in storage, which moisture enables the micro-organisms to grow and deteriorate the sugar. Studying a chart of the relative humidity and temperature at Durban during the year, those who handle sugar will at once perceive that the periods when they are most troubled by "sweating" and deterioration are during the months when the relative humidity and temperature are highest. . . . . .

Temperature.

Next to moisture the most important factor in sugar deterioration is probably the temperature. It has been suggested that cool storage should be combined with dry storage. In this connection Owen cites the following suggestive and interesting experiment: Samples containing sufficient moisture to enable them to deteriorate were placed respectively in (1) a refrigerator at approximately 20° C., (2) in an incubator at 34° C., (3) left at room temperature. In every instance the refrigerator sample deteriorated slightly as compared with the others. These results are, of course, based on the fact that the lower temperatures retarded the growth of the organisms. In Table XXVI below we give results obtained in Dox's solution, inoculated with our Sterigmatocystis fungus and incubated at (1) 30° C., (2) room temperature, (3) ice chest.

TABLE XXVI.—ANALYSIS FOUR DAYS AFTER INOCULATION.

	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert sugar in 100 c.c.
Control	.1	—
30° C.	.45	1.5
Room temperature (19°—23° C.)	—	.1
Ice-chest (11°—15° C.)	No evident growth of fungus and analysis similar to control.	

Earlier in this paper we have noted the resistance to heat which the different organisms show. The fungi we note are readily killed by the temperature of boiling water, whereas the bacteria are very resistant. Fortunately we now know that bactèria are not the main causes in sugar deterioration. They appear to exert an action on crystal sugar only when the moisture content is abnormally high, and further they cannot thrive in such high densities as the fungi. The main agents in sugar deterioration—the fungi—readily succumbing to heat may suggest the sterilization of sugars, but even when sterilized subsequent infection would still have to be guarded against.

I believe they are in Louisiana at present studying the possibility of actually

sterilizing the sugar and washings in the centrifugals by means of super-heated steam. It is also primarily from this viewpoint that previous workers have suggested the substitution of water by steam at the centrifugals.

Kammerling has suggested that deterioration of sugars is produced by micro-organisms introduced from the bags and recommended their disinfection in a 1 per cent solution of carbolic acid. Results in Prinsen Geerlig's "Cane-sugar and Its Manufacture," however, show that no benefit is derived from such disinfection, probably because the sugars may carry the germs causing deterioration before being bagged. It should, however, be mentioned that the fungoid threads offer an easy means for penetrating the bags and especially if they should come in contact with material containing the germs. This should suggest that the storehouses should be kept scrupulously clean and all filth (may be slimy masses of fermented sugar, etc.) removed, and that the floors and walls of the building may possibly be disinfected.

Contaminated wash water has been held as a source of infection of sugars, and Noel Deer observed an instance where the deterioration was due to the cooling-tower water used in washing at the centrifugals. Browne regards the cooling-tower water as the most dangerous source of infection. As he points out, it contains sugar lost by entrainment, and is very favorable for the growth of micro-organisms. He further writes that the spray from the cooling-tower is carried into the factory, where it comes into contact with bags and sugars. Attention has been called to the possible infection of sugar through bagasse particles which find their way into raw sugars. This was more fully investigated by Owen, and his conclusion is that these particles only influence deterioration by the absorption and retention of moisture, thus creating moist zones in which deterioration can take place. He does not attach much importance to the view that the bagasse particles carry the germs, and holds that the most dangerous infection of sugars takes place in the centrifugals. He recommends the use of covered centrifugals.

It is the general opinion that in mills the infection takes place chiefly at the centrifugals, and this may in some measure be due to the air sucked through with the rapid revolving of this machine, as has been suggested. Probably covering the sugar conveyances to the centrifugals, and also from the centrifugals, would also remove some sources of infection.

Generally speaking, more and more stress is being laid upon the importance of cleanliness in the factory as a preventive in the deterioration of mill sugar. It is thought that the experiments with antiseptics recorded in this paper may be of some value in this connection.

From reports it would appear that in Hawaii losses from sugar deterioration have been almost eliminated, and there the correction of this trouble is generally believed to be due to the improved cleanliness in the factory.

It would to the writer appear wrong to attach too great importance to any one particular source of infection. Recognizing that the molds responsible for sugar deterioration are common ones and by no means limited to sugar only, it would appear that after the sugar leaves the pans it should be handled under conditions as hygienic as possible, whether these conditions involve the periodical disinfection of floors, etc., in the mills, the disinfection of mills in the off-season

or any other precaution. Similarly in storage, the conditions should be hygienic and as far as practicable tend to keep the sugar dry and cool and prevent moisture absorption during unfavorable weather conditions.

In our experiments with the various disinfectants we do not necessarily mean to suggest that they are all equally suitable for use in factories, etc. Among the main considerations should be their cheapness and whether they are easily procurable. Formalin, chloride of lime and milk of lime appear to be the three most suitable. Milk of lime should be useful for disinfecting the walls and ceilings of storehouses, etc., and cleaning the tanks. Chloride of lime has a high germicidal power, and should be specially useful for disinfecting filter bags and tanks containing fermented juices. It remains only to mention that these disinfectants are more efficient at higher temperatures and are hence in the disinfection of sugar factories preferably used hot.

Natal Herbarium, Berea, Durban, September, 1919.

[C. W. C.]

SUGAR PRICES FOR THE MONTH

Ended October 15, 1921.

		96° Centrifugals		Beets	
		Per Lb.	Per Ton.	Per. Lb.	Per Ton.
	(Sept. 16, 1921)......	4.00c	$ 80.00		
	" 22............	4.3125	86.25	No quotation.	
	" 23............	4.50	90.00		
	" 27............	4.21625	84.325		
[1]	" 28............	4.125	82.50		
[2]	" 29............	4.205	84.10		
[3]	" 30............	4.1175	82.35		
	Oct. 3............	4.2133	84.266		
	" 6............	4.23	84.60		
	" 10............	4.125	82.50		
	" 11............	4.23	84.60		
[4]	" 14............	4.11	82.20		

[1] Domestic.

[2] Cubas 4.11. Export 4.30.

[3] Cubas 4.11. Domestic 4.125.

[4] Cubas.

THE HAWAIIAN PLANTERS' RECORD

Volume XXV. DECEMBER, 1921 Number 6

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

H 109—A Study in Variation.

By W. W. G. Moir and E. L. Caum.

The most invariable thing in Nature is variation.

Organic selection, or, as it is more commonly known, natural selection, is the selection carried on in plants and animals by Nature herself. It is based on the ability of the organism to adapt itself to its environment and to flourish in that environment, without regard to any other factor. All that is required is that it obey the Biblical injunction to "increase and multiply." If it cannot do that under the existing conditions it is eliminated, and its place is taken by one that can.

Contrasted with natural selection is what may be called, for want of a better term, artificial selection. Bud selection is artificial selection applied to plants. This type of selection consists in altering or adapting Nature's methods to human use.

No species of organisms is absolutely fixed. "Variations (V) occur, some of which are in the direction of increased adaptation (+); others in the direction of decreased adaptation (—). Acquired modifications (M) also occur. Some of these are in the direction of increased accommodation to circumstances (+), while others are in the direction of diminished accommodation (—). Four major combinations are:

(a) +V with +M	(c) —V with +M
(b) +V with —M	(d) —V with —M

Of these (d) must inevitably be eliminated while (a) are selected. The predominant survival of (a) entails the survival of the adaptive variations which are inherited. The contributory acquisitions (+M) are not inherited, but they are none the less factors in determining the survival of the coincident variations."

The preceding paragraph, which is quoted from "Darwin and Modern Science", chapter by C. L. Morgan, was written to apply to organic selection, but it is equally applicable to the other type. The four combinations are the same, the difference lying in the characteristics represented by the letters V and M. In organic selection they refer to factors which determine the actual existence of the organism, whereas in bud selection they refer to factors which determine the economic value of the plant.

An erect type of H 109 at the age of 3½ months.

All plants vary, and these variations are of three main types—those which are valuable, those which are of no particular significance, and those which are detrimental. The second class need not be considered. The principles of bud selection are to isolate and preserve the +V+M plants, to hold for observation the +V—M plants, and to eliminate the —V+M and —V—M plants.

In sugar cane we have a number of constitutional varieties which, to avoid confusion in terms, may be provisionally referred to as species. Taking, for example, H 109, and letting V refer to type of stooling and M to number of sticks per stool, we have the following combinations:

+V+M = a deep-rooted stool with many sticks (4, 10, pp. 275, 279);
+V—M = a deep-rooted stool with few sticks (6, p. 279);
—V+M = a shallow-rooted stool with many sticks (1, p. 272); and
—V—M = a shallow-rooted stool with few sticks (2, p. 273).

Other characters might be used equally well. Erectness or recumbency of sticks is an inherited character as well as shallow or deep rooting, and size of sticks is dependent on environment, just as is number of sticks. We should preserve the deep-rooted, erect stools and discard the shallow-rooted, recumbent types, at the same time so modifying the conditions under which they must grow as to make the M's all +; in other words, suit the agricultural practice to the cane so that each stool will produce a maximum number of large sticks rather than a few small ones.

In the October, 1921, number of the *Record* was published a progress report on the bud selection work carried on by this Station, in which it was stated that there existed in our standard canes various types or strains which could be isolated. Since that report was written there has been further study made of the strains of H 109, a discussion of which follows.

Definition of Terms.

Color: The types are classed in three great color groups. This critical color is seen only on the upper part of the stick from which green leaves have just been removed. The color changes rapidly on exposure and ceases to be critical.

Stooling: (a) Bird's-nest. Shallow stooling, the sticks all arising very near the surface of the ground. The term "bird's-nest" is in itself rather a good description of this type.

(b) Standard. Deep stooling, the sticks arising well below the surface of the ground in a fairly compact group.

(c) Nondescript. A few scattered sticks, the stool type of which cannot be properly classified.

Manner of Growth: (a) Recumbent. The sticks of this type of stool all have a tendency to lie flat on the ground, this tendency making its appearance at a very early stage.

(b) Erect. In this type of stool the sticks all tend to stand upright and fairly close together.

(c) Semi-erect. This type is intermediate between the other two. The sticks do not stand upright, but neither do they lie along the ground. They tend to grow rather at an angle. In all these types the growth characters are best seen in young cane, because in older canes, where the sticks have attained considerable length, their weight is often sufficient to make the identification of types impossible.

Shape of Sticks: The shape, oval or round, as seen in cross-section.

Miscellaneous: Lala. The eyes on the upper part of the stick have a tendency to sprout when the cane is but one year old. These premature lalas prevent the normal elongation of the stick and, unless there is an excess of water available, they soon dry up, leaving the stick considerably stunted.

The types or strains of H 109 may be classified as follows:

- I. Green.
  - A. Bird's-nest
    - 1. Recumbent (1)
  - B. Nondescript
    - 1. Recumbent (2)
- II. White
  - A. Bird's-nest
    - 1. Semi-erect (3)
      - a. Short-jointed
      - b. Lala
  - B. Standard
    - 1. Semi-erect (4)
      - a. Oval sticks
      - b. Lala
    - 2. Erect (5)
      - a. Normal
      - b. Lala
    - 3. Very erect (6)
      - a. Short-jointed (turns red on exposure)
      - b. Long-jointed (turns purple on exposure)
      - c. Lala
- III. Orange
  - A. Bird's-nest
    - 1. Semi-erect (7)
      - a. Normal
      - b. Lala
  - B. Nondescript
    - 1. Recumbent (8)
  - C. Standard
    - 1. Semi-erect (9)
      - a. Staggered-jointed normal
      - b. Lala
    - 2. Erect (10)
    - 3. Very erect (11)
      - a. Critical color light buff (rare)
      - b. Critical color dark buff

Discussion of Types.

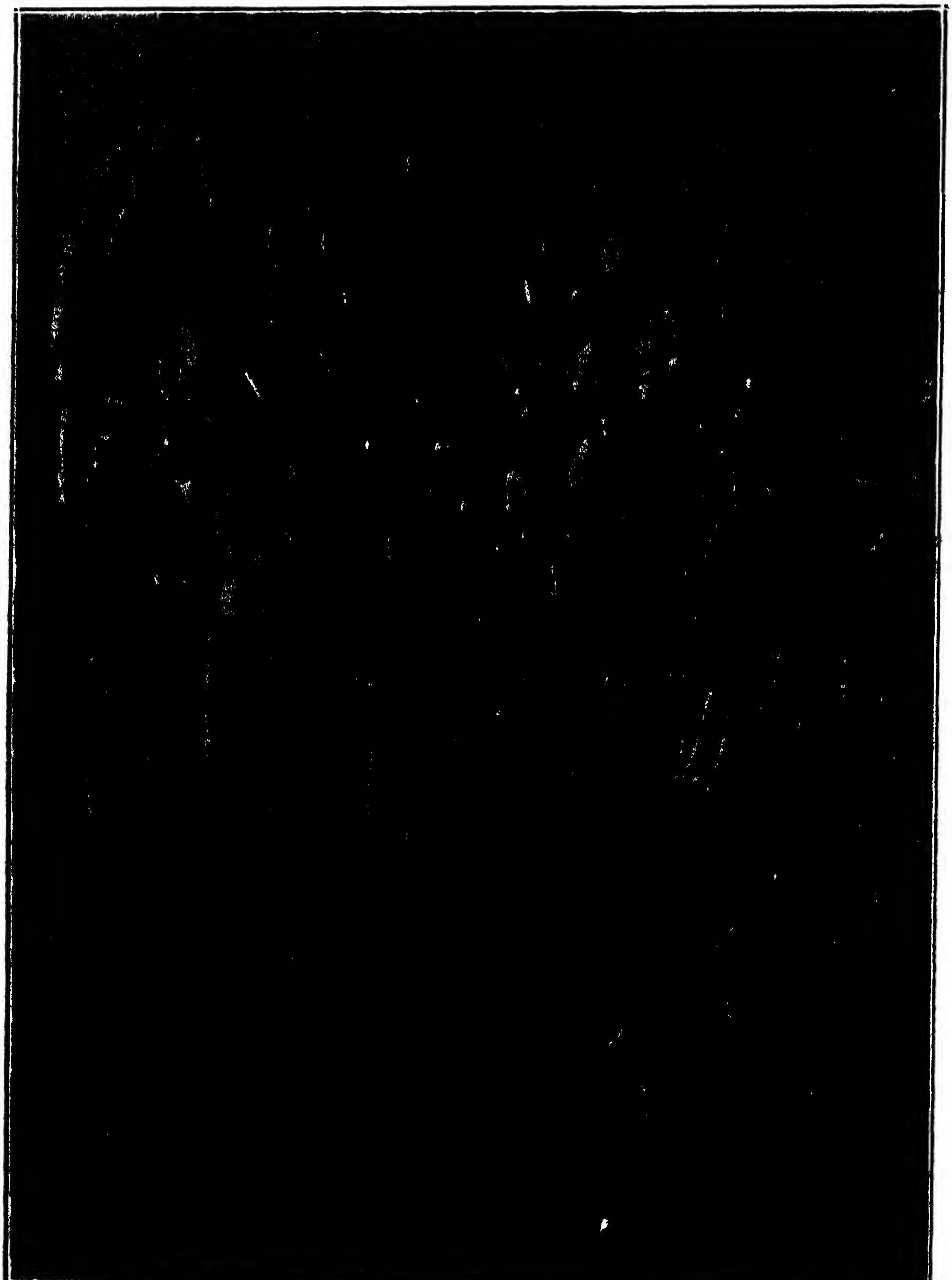
(1.) This type forms a stool of many extremely recumbent, medium-sized sticks. The short, sausage-shaped joints, which have a dried-out appearance, are at first olive green, soon turning lavender on exposure. With longer exposure the color changes to deep yellow, the shade of weather-beaten Lahaina cane. The sticks are of fair size at the base, but soon begin to taper out, many dying before reaching maturity. Due to the recumbent position of the sticks, many of the lower joints strike root, causing the eyes to sprout. This, besides lowering the

sucrose content of the stick, causes the production of a great number of weak shoots which soon die out. Although weak, this type is able to maintain itself to some extent for several crops, once it has become established. In the ratoons it produces many small, weak shoots which die under severe competition, so that frequently a field which seems to need no replanting when the ratoon shoots first appear has many gaps when the crop is harvested. For its full development this type needs an open position with plenty of sunlight and water, and where it is protected from the direct winds.

(2) This type, which is quite common, produces so few sticks per seed piece that they can hardly be dignified by the name "stool". The long, slender, soft, green joints turn to a light lemon yellow on exposure. Under direct sunlight

A recumbent type of H 109 at the age of 3½ months.

large red blotches appear on the internodes. With very favorable soil and water conditions canes of this type may develop good-sized sticks, but their softness makes them very susceptible to damage by drought and leaf-hopper, with a resulting lowering of the sucrose content. The recumbency is noted when the cane is but a few months old, for by that time the short sticks are lying prostrate. They are easily choked out by more erect types and are extremely subject to mechanical injury. In their efforts to push their leaves out into the sunlight the sticks become long and spindling, and many die under the severe competition which they must undergo. The eyes on these sticks are small, sunken and poorly developed. Many plantation men favor these small-eyed slender sticks as planting material because of the greater ease in handling and the greater area planted per bag of



The semi-erect white type of H 109, in a very favorable position.

seed. These advantages, however, are more than offset by the considerable amount of replanting that is necessary, and by the poor yield from the sticks that reach maturity. These slender, small-eyed canes are weak. They must have the best possible growing conditions if they are to survive, and among these conditions is an abundance of water—far more than is required by the heavier types.

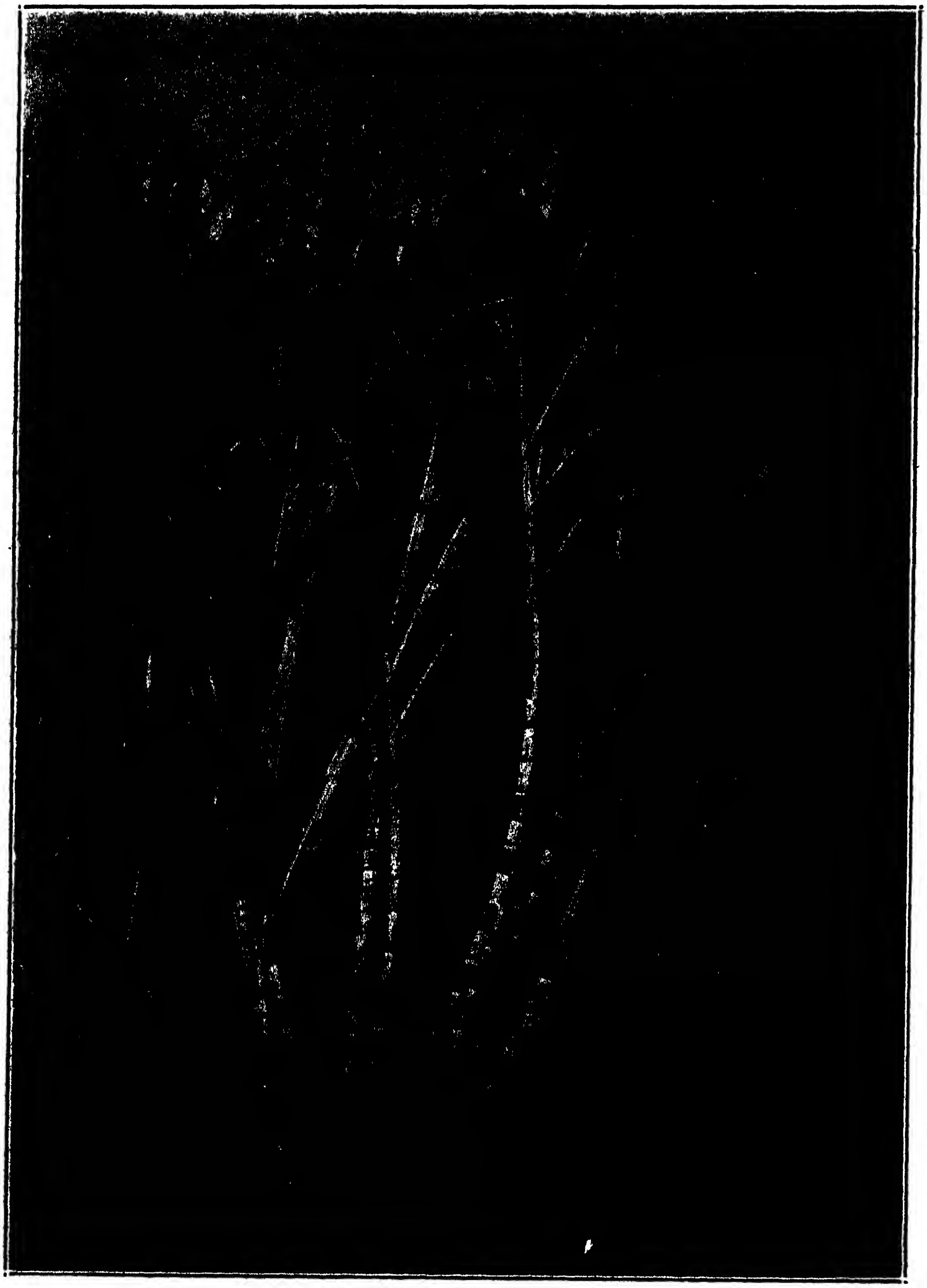
Both these green types are extremely undesirable from an economic viewpoint, and pains should be taken to eliminate them from our fields.

(3) This white bird's-nest type, although undesirable, is superior to the green. Its many short-jointed sticks are so shallowly rooted that unless extra

H 109, 3½ months old. Note the difference between the erect type on the left and the recumbent type on the right.

care is given in the way of increased fertilization and irrigation, and unless the soil is pulled up around the stool, short, stunted sticks will be produced. A large patch of this type of cane is very noticeable in a field. A stool of this strain growing along a level-ditch or water-course will often appear excellent, but seed from it, planted under normal conditions, will give a mediocre crop. The lala-producing character is extremely common in this type, so by selecting against the prematurely-lalaing stools it may be eliminated to a great extent.

(4) A stool of this type consists of a compact group of semi-erect, waxy-white, oval sticks, which on exposure turn first to a dark green and then to bluish purple. The sticks are very large in circumference and short-jointed in the lower part, the upper part producing joints of a good length. Although not



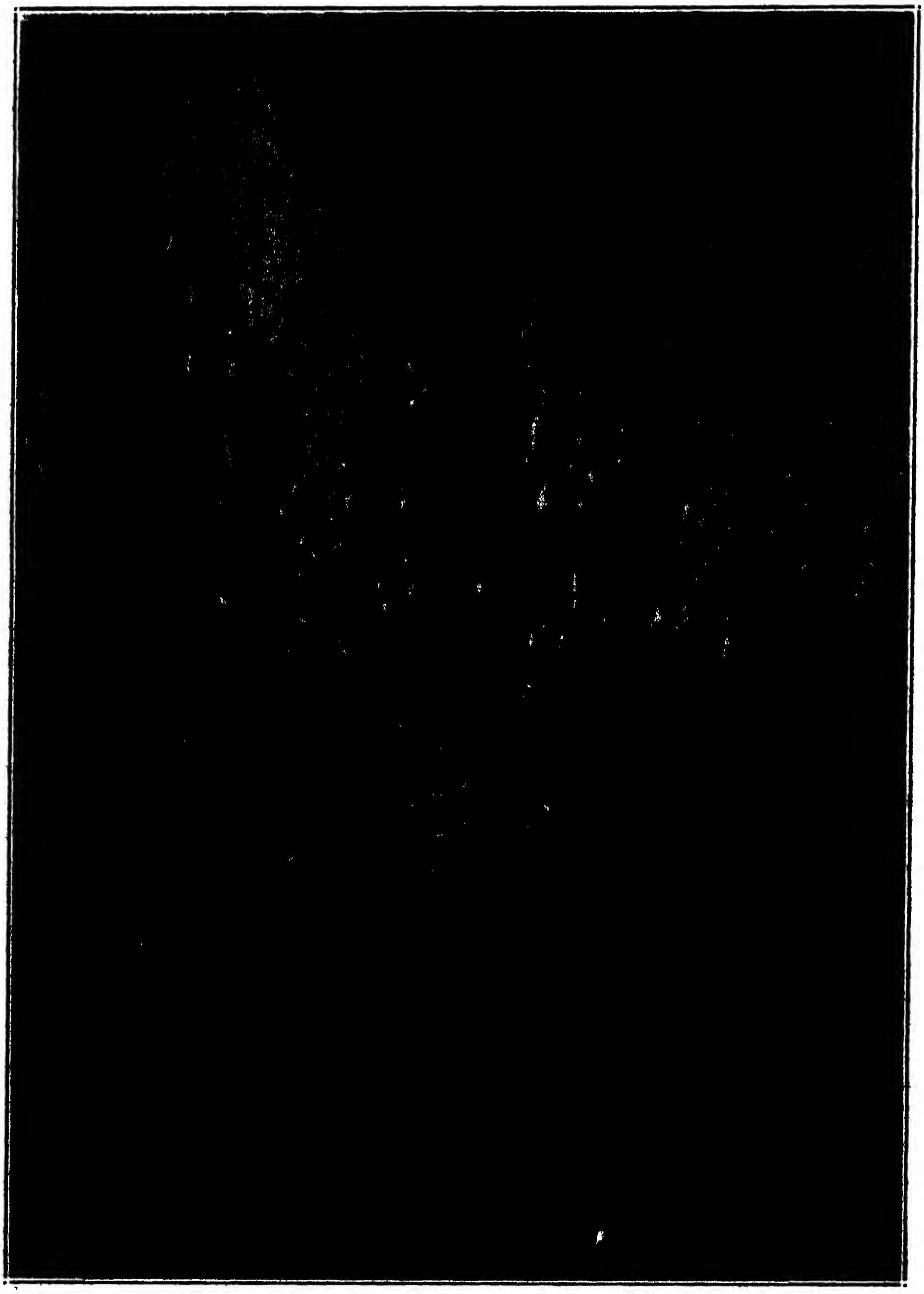
A recumbent type of H 109. Note the tendency to shallow rooting, the tapering sticks and spindling tops, in spite of the fact that the stool is growing in an especially favorable position.

as rapid a grower as the erect type, it is the first to "close in". It begins to stool out as soon as the primary shoot is a few inches high, and maintains this even stooling until the row is filled. It produces few sticks in comparison with the bird's-nest types, but what it does produce it carries through to maturity. Cane of this type should be excellent for late planting. A lala variety of this type exists, but fortunately is not common.

(5) This type is slightly more erect than the one described above. The sticks are round rather than oval, and are larger than the average. Stools of many stalks are occasionally found, but tonnage is obtained from the length

A semi-erect type of H 109 at the age of 3½ months.

and diameter of the sticks rather than from the number. This type, like all the other erect types, has a very heavy, waxy bloom, and leaves which are rather larger and more erect than ordinary and somewhat deciduous, as are the sheath hairs. In these respects this type contrasts strongly with those described above. Canes of this type stool out much more slowly than do those of type (4), but the late shoots are such strong and rapid growers that they soon find their "place in the sun". As a ratooning cane this type is excellent. It produces, not a great number of small shoots, most of which soon die, but a few well-placed sturdy ones which pull through to maturity.



A stool of the long-jointed very erect white type of H 109, under exceptionally good growing conditions.

(6) The very erect white types are of two kinds, one long-jointed and vigorous, the other short-jointed and less vigorous. A lala variety has been found, but the few examples noted have all belonged to the second kind, which is a poor stooling cane with rather short, straight sticks made up of short joints telescoped together. Under ideal conditions the first year's growth is rapid. The growth during the second year is much slower, resulting in many short, stubby joints. When the leaves are stripped from the upper part of the stick the white color turns after a few hours' exposure to a deep red and later to a deep reddish purple. This variety of erect white is unproductive, and should be eliminated.

The long-jointed erect white type is very uncommon, only one good example having been seen. The joints are long, fairly straight, and covered with a peculiar network of fine lines. The sticks on exposure remain very light purple. The eye is fairly large and set close to the stick. In a district where high winds prevail this type would be undesirable, as it is very brittle and easily broken off at the base. In stooling and ratooning properties it is very similar to type (5).

(7) The only differences between this type and type (3) are in the color, which is a decided orange instead of white, and in the longer joints. It seems to be very adaptable to conditions as it finds them, but in spite of this it is sufficiently undesirable to warrant elimination.

(8) An orange type very similar to the green described as type (2) is often found on Oahu. The long, very slender stick is not attractive in appearance. The stools are small, recumbent, and easily shaded out. On exposure these canes turn to dark bronze purple. This type seldom produces a large stick, so that elimination in the field is easily accomplished by discarding all small-stalked stools.

(9) This orange type closely resembles the white type (4), except that the sticks are round in cross-section rather than oval, and that the joints are longer and slightly smaller in diameter. As the sticks increase in length they tend to become recumbent. Stools of this type never consist of very many sticks, but the individual sticks are frequently of great length, often 25 or 30 feet. This type is neither exceptionally good nor exceptionally poor, but should be preserved for further study.

(10) This is an excellent type, differing from type (5) only in the critical color. In some localities this type seems to predominate, and from the juice figures obtained from those fields it would appear to be one of the most valuable strains of the variety. Incidentally, this strain is the one most frequently chosen as "typical H 109".

(11) This very erect type is so decidedly orange in color and has so little bloom that it is easily identified. Some variations in intensity of color exist, but they are of minor importance. The sticks are never very large or very long, and the staggered joints are of uniform diameter. Under exposure the orange color changes to deep bronze, overlaid with purple. On a "tonnage per acre" basis this type is mediocre, and should be replaced by better ones.

Slight variations exist in many of the above types—gradations from one type to the next within the color group, variations in shape and size of the eye, and other minor differences. Since many of these are obviously due to the environ-

A mixed stool of H 109. The five sticks at the left are of the erect orange type, while the five at the right are semi-erect white.

ment, however, and others are correlated with more decided type characteristics, they will not be discussed at this time.

In addition to these strains, there are several distinct mutations or sports known. These are striped canes, which to all outward appearances differ from the basic types from which they originated only in the fact that the sticks are striped instead of self-colored. They may differ in other ways, but lack of data due to their rarity precludes their discussion.

It should be noted here that the data on which these notes are based were obtained on Maui. It is altogether probable, however, that the types of Oahu, Hawaii and Kauai will be comparable to those of Maui, if not identical with them.

Conclusion.

The constitutional cane variety known as H 109 is composed of many distinct strains or types, some of which are of great value economically, while others are decidedly inferior and detrimental to our tonnage yields.

The most desirable strains, and the ones which should be spread as rapidly as possible, are those described as types (4), (5), (9) and (10). A general and speedy elimination of the following classes would materially improve the quality of our H 109 fields:

1. All green types.
2. All bird's-nest and nondescript stool types.
3. All very recumbent and very erect types.
4. All lala types.

With these nonproductive types eliminated, the plantations of Hawaii would be well on their way toward getting the maximum yield from this standard variety. Mass plantings of the four types named as desirable would furnish valuable material for progeny test plantings. In connection with this it should be remembered that the fact that a selected stool of cane happens to be predominantly one of the desirable types does not necessarily mean that selection should stop there. All the stools of a given type group are not of the same quality, and progeny test plantings are necessary if the maximum-yielding strains of this group are to be isolated and brought up to plantation acreage.

Experiments at Pioneer Mill.

PIONEER MILL CO. EXPERIMENTS 1, 2, 3, 4, AND 5, 1921 CROP.

During August, 1921, we harvested five experiments at Pioneer Mill Company. These were located in the Kaanapali Section in Field B-6, at an elevation of about 420 feet. The cane was plant, planted in July, 1919. Except in Experiment No. 1, which was a variety test, the cane was Striped Mexican.

The experiments were irrigated about every 30 days from August, 1919, to November, 1920, and had one irrigation in May, 1921. During this time this field got 28 inches of rain. At the time of harvest the cane was rather dry.

PIONEER MILL CO. EXPERIMENT NO. 1, 1921 CROP.

Variety Test.

This was a variety test with plant cane in which D 1135, H 109, Striped Mexican, H 33, Lahaina, and H 146 were compared.

The results obtained at harvest are given in the following tabulation:

No. of Plots	Variety	Yield per Acre		
		Cane	Q. R.	Sugar
10	D 1135	51.5	6.93	7.44
10	H 109	44.6	6.75	6.60
10	Lahaina	41.4	6.70	6.17
10	Striped Mexican	44.2	7.18	6.16
10	H 33	43.4	7.69	5.64
10	H 146	30.2	7.49	4.03

Under the conditons of this experiment where a shortage of water existed, D 1135 proved the better cane, followed by H 109. The other varieties were distinctly inferior; H 146, especially, was a failure. During the last two or three years this variety has been doing very poorly and should not be planted on any extensive areas. It is a poor ratooner and is susceptible to Lahaina disease.

It is interesting to note that in this experiment the D 1135 juices were practically as good as were those of the H 109 or Lahaina. We believe that, in the majority of cases, where very poor juices are reported from D 1135 cane, that they are due to the presence of immature suckers. The age of suckers when harvested has a very important bearing on the yields obtained from D 1135.

DETAILS OF EXPERIMENT.

Object:

To compare H 33, H 109, H 146, D 1135, Striped Mexican, and Lahaina.

Location:

Pioneer Mill Co., Field B-6, Kaanapali Section.

Layout:

Number of plots = 60.

Size of plots = 1/20 acre, consisting of 7 rows two watercourses long; by measurement, 31.5′ x 69.15′ from center to center of watercourses.

Each row = 4.5′ x 69.15′.

Crop:

H 33, H 109, H 146, D 1135, Striped Mexican, and Lahaina; plant crop.

Plan:

Fertilization—Two doses of high grade and two doses of nitrate of soda, amounting to 200 pounds of nitrogen and 120 pounds of P_2O_5, per acre, uniform or regular plantation practice.

Experiment planned by J. A. Verret and L. T. Lyman.

Experiment laid out by L. T. Lyman.

Exp. 1. Variety Test.

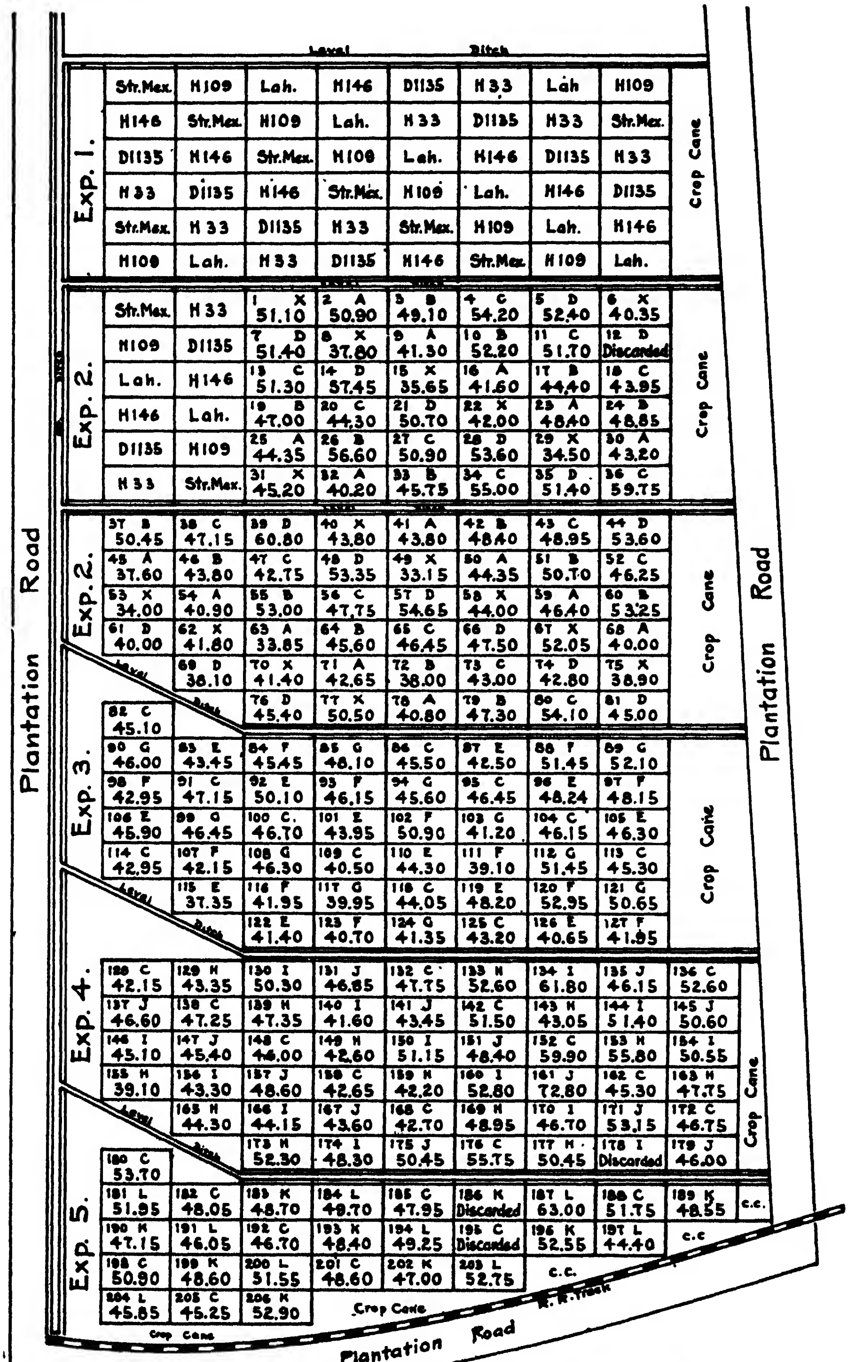
Exp. 2. Amount of Nitrogen to Apply.

Exp. 3. Phosphoric Acid Requirements.

Exp. 4. Plant Food Requirements.

Exp. 5. Number of Applications.

Pioneer Mill Co. Expts. 1, 2, 3, 4 & 5, 1921 Crop



Note – 12 plots on left of upper Exp. 2. = Exp. 1. Others = Exp. 2.

PIONEER MILL CO. EXPERIMENT NO. 2, 1921 CROP.

Amount of Fertilizer to Apply.

This was a test to determine the economic limit in fertilization under conditions of a certain amount of water shortage.

During the first year a mixed fertilizer was used. This fertilizer contained 10% nitrogen, 7% phosphoric acid, and 3.75% of potash. Nitrate of soda was used during the second growing season.

The amounts of fertilizer used and the yields obtained are tabulated as follows:

Pounds per Acre		Pounds of Nitrogen	Yield per Acre		
Mixed Fert.	Nit. of Soda		Cane	Q. R.	Sugar
0	0	0	42.2	6.49	6.50
500	322	100	43.5	6.61	6.58
750	484	150	48.4	6.55	7.39
1000	645	200	49.2	6.82	7.22
1250	806	250	49.4	6.76	7.30

The results obtained from the fertilizer here were not specially striking and did not extend above 150 pounds of nitrogen per acre, obtained from 750 pounds of high grade the first year, and 484 pounds of nitrate of soda the second year.

DETAILS OF EXPERIMENT.

Object:

To determine the economic limit of nitrogen as a fertilizer on the lands of Pioneer Mill Co. that have been cropped for many years.

Location:

Pioneer Mill Co., Field B-6.

Crop:

Striped Mexican, plant.

Layout:

No. of plots = 81.

Size of plots = 1/20 acre; each plot is 7 lines by 2 watercourses, each line being 4.5′ wide by 69.15′ long.

Plan:

POUNDS NITROGEN PER ACRE.

Plots	No. of Plots	Sept. 1, 1919	Nov. 1, 1919	Feb. 15, 1919	Apr. 15, 1919	Total Nitrogen
X	16	0	0	0	0	0
A	16	25	25	25	25	100
B	16	37.5	37.5	37.5	37.5	150
C	16	50	50	50	50	200
D	17	62.5	62.5	62.5	62.5	250

Mixed fertilizer first season—10% N. (3½ N. S., 5 Sulf. Amm., 1½ Org.), 7% P_2O_5 (Super.), 3.75% K_2O.

Nitrate of soda second season—15.5% N.

Experiment planned by J. A. Verret and L. T. Lyman.
Experiment laid out by L. T. Lyman.

PIONEER MILL COMPANY EXPERIMENT NO. 3, 1921 CROP.

Phosphoric Acid Test.

In this experiment varying amounts of phosphoric acid were tried. The results obtained are tabulated below:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
No phosphate	44.8	7.18	6.24
60 lbs. phosphoric acid (P_2O_5)....	44.4	7.35	6.04
100 lbs. phosphoric acid (P_2O_5)....	45.3	7.24	6.26
140 lbs. phosphoric acid (P_2O_5)....	46.3	7.22	6.41
Average of all P_2O_5 plots	45.3	...	6.24

There is apparently some response to phosphates in this test, but the response is slight and somewhat contradictory. The average yield of sugar from the no-phosphate plots was the same as that from the plots which had phosphate. This may be due to some experimental error, as indicated by the gradual increase in yields as the amounts of P_2O_5 used were increased from 60 to 140 pounds per acre. This increase amounts to about 0.2 ton of sugar for each 60 pounds of P_2O_5.

On account of the slight differences between the various treatments it is considered best to await the results from the next ratoon crop before arriving at any definite conclusion.

DETAILS OF EXPERIMENT.

Object:

To determine the profitable limit in the application of phosphoric acid.

Location:

Pioneer Mill Co., Field B-6, Kaanapali Section.

Crop:

Striped Mexican, plant.

Layout:

46 plots, each 1/20 acre, 7 lines 2 watercourses long. Each line 4.5′ by 69.15′ from center to center of watercourse.

Plan:

FERTILIZATION* — POUNDS PER ACRE.

Plots	No. of Plots	Nitrogen, Sept., 1919	Phos. Acid, Sept., 1919	Nitrogen			Total Pounds	
				Nov., 1919	Feb., 1919	Apr., 1919	N.	P_2O_5
C	11	50	0	50	50	50	200	0
E	12	50	60	50	50	50	200	60
F	12	50	100	50	50	50	200	100
G	11	50	140	50	50	50	200	140

* P_2O_5 from superphosphate = 16% P_2O_5.
Nitrogen from nitrate and sulphate mixture = 17½% N.

PIONEER MILL CO. EXPERIMENT NO. 4, 1921 CROP.

Phosphoric Acid and Potash Test.

This was a test to determine the needs for phosphoric acid and potash of the soils in the Kaanapali section of this plantation.

In this experiment slight gains were obtained from both potash and phosphoric acid. The gain from potash alone amounted to about one ton of cane per acre. A gain of this nature is too small to be accepted as definite.

The plots getting both phosphoric acid and potash show larger gains, amounting to about 0.3 ton of sugar per acre.

The yields obtained in Experiment No. 4 were as follows:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Nitrogen only	48.4	6.73	7.19
Nitrogen and Potash (100 lbs. K_2O)	48.9	6.69	7.31
Nitrogen and Potash (200 lbs. K_2O)	49.4	6.71	7.36
Nitrogen, Phos. Acid and Potash	50.8	6.71	7.57

DETAILS OF EXPERIMENT.

Object:

To determine the plant food requirements of sugar cane under conditions at Pioneer Mill Co.

Location:

Pioneer Mill Co., Field B-6.

Crop:

Striped Mexican, plant.

Layout:

No. of plots = 66.
Size of plots = 1/20 acre, consisting of 6 lines, each line being 5′ wide by 72.6′ long.

Plan:

Plots	No. of Plots	Sept. 1, 1919			Nov. 1, 1919	Feb. 15, 1920	Apr. 15, 1920	Total Pounds per Acre		
		N.	P_2O_5	K_2O	N.	N.	N.	N.	P_2O_5	K_2O
C	13	50	...	...	50	50	50	200	...	...
H	13	50	100	100	50	50	50	200	100	100
I	13	50	...	100	50	50	50	200	...	100
J	13	50	...	200	50	50	50	200	...	200

N. = 17½% mixture = ½ nitrate soda = ½ amm. sulp.
P_2O_5 = acid phosphate 16%.
K_2O = sulp. potash 50%.

Experiment planned by J. A. Verret and L. T. Lyman.
Experiment laid out by L. T. Lyman.

PIONEER MILL CO. EXPERIMENT NO. 5, 1921 CROP.

Fertilizer — How to Apply.

In this experiment we tried applying a given amount of fertilizer in two, three and four doses. A total of 200 pounds of nitrogen per acre was used. Half of this nitrogen was from a mixed fertilizer containing 10% nitrogen, 7% phosphoric acid, and 3.75% potash. The other half, applied during the second season, was from nitrate of soda.

The yields obtained from the different treatments were identical, as shown below:

No. of Applications	Yields per Acre		
	Cane	Q. R.	Sugar
Two applications	49.2	7.16	6.88
Three "	48.9	7.16	6.84
Four "	49.1	7.16	6.86

The results obtained from this experiment confirm those obtained from our other experiments on this subject. There is nothing to gain by applying fertilizer in more than two or three doses per two-year crop.

DETAILS OF EXPERIMENT.

Object:

To determine the most profitable number of applications in which a given amount of fertilizer should be applied.

Location:

Pioneer Mill Co., Field B-6.

Crop:

Striped Mexican, plant.

Layout:

No. of plots = 27.

Size of plots = 1/20 acre; each plot is 7 lines by 2 watercourses, each line being 4.5′ wide, 69.15′ long. One guard row along level ditch.

Plan:

POUNDS OF NITROGEN PER ACRE.

Plots	No. of Plots	Sept., 1919	Nov., 1919	Feb., 1920	Apr. 1, 1920	Total Nitrogen per Acre
C	9	50	50	50	50	200
K	9	100	0	100	0	200
L	9	50	50	100	0	200

First season, mixed fertilizer = 10% N. (3½ N. S., 5 Sul., 1½ Org.), 7% P_2O_5 (Super.), 3.75% K_2O.

Second season nitrate of soda = 15.5% N.

Experiment planned by J. A. Verret.
Experiment laid out by L. T. Lyman.

J. A. V.

Artificial Farmyard Manure.*

An article in the August issue of the Journal of the Ministry of Agriculture under the above title somewhat modestly announces what must be regarded as one of the most notable advances in agricultural science made by our oldest agricultural research laboratory, the Rothamsted Experimental Station. For many years the composition and fertilizing value of farmyard manure have occupied the attention of investigators. The chemical problems involved at first sight appear simple. When cattle are fed with food rich in nitrogen there is a corresponding enrichment of their excrement. "Cake-fed" dung has long been given a high value by the farmer, and on a purely chemical basis its merit was recognized by the man of science. Hence such publications as "Hall and Voelcker's Tables," which give the "residual" values of various foodstuffs—that is to say, the value of the fertilizing constituents (mainly nitrogen) in various substances present in the dung of animals to which they have been fed. But the perplexing fact emerged that dung with this higher theoretic value did not give crop increases corresponding to its assumed chemical content. Nevertheless, so strong has been the effect of the publication of these theoretic values that they are given quasi-statutory effect. Entering tenants have generally to pay compensation "for improvements" based upon the quantity and quality of the foods consumed on the farm during the years preceding their entry.

In the paper alluded to, Messrs. Hutchinson and Richards indicate the solu-

* From Nature, August 25, 1921.

tion of the conundrum. Put shortly, they have established that the whole of nitrogen in the urine of animals will not be present in the manure as applied to the crops unless a certain ratio subsists between the nitrogen voided by the animals and the carbonaceous matter of the litter by which the urine is absorbed. It seems to follow that "compensation for improvements" should not be awarded on the basis of the food supplied to the stock until the valuer is assured that the feeding was accompanied by an adequate supply of litter, the adequacy being determined by the amount of nitrogen voided by the animals.

Messrs. Hutchinson and Richards show that the factors involved are, in the main, biological, not chemical. The "making" of farmyard manure is essentially the rotting or fermentation of straw. The former writer has published a paper (Journal of Agricultural Science, 1919, p. 143) which establishes that straw is fermented by a new aerobic organism, *Spirochaeta cytophaga,* and that this organism requires (in addition to air) a supply of nitrogen, preferably in the form of an ammonia compound (such as, in effect, urea is). It is shown that the amount of nitrogen required for the fermentation of 100 pounds of straw is 0.72 pound. Further, if the nitrogen is in excess of this amount, it tends to pass into the atmosphere as ammonia, with the result that, with a free supply of air, the end product is dung containing about 2 per cent of nitrogen, whatever the original content of the excrement may have been. Under the conditions, however, which obtain in the ordinary farmyard, where some portions of the heap may receive more excrementitious matter than others, the ammonia set free where the nitrogen : cellulose proportion is greater than 0.72 : 100 may be picked up by those portions where the ratio is less, and used to build up their nitrogen content until the whole heap reaches the characteristic and uniform 2 per cent content of nitrogen.

Using these results, it has been found possible to make an artificial product, closely resembling farmyard manure in appearance as well as in properties, by the addition of predetermined amounts of ammonia salts (such as ammonium sulphate) to straw. The commercial value of this development may be considerable. With the advent of the motor the supply of town dung has fallen off. Many market-gardeners are, consequently, in straits, for the so-called artificial manures are lacking in organic matter (humus), without which many garden and glasshouse crops cannot be grown satisfactorily. It may be that the ordinary farmer, too, will find a use for the artificial product. It is difficult under modern conditions to maintain sufficient animals to make all the straw produced into dung. Again, where animal excrements exist in abundance (as in milk production), lack of knowledge of the principles of the interaction between urine and straw leads to much waste of valuable fertilizing material.

Another direction in which these discoveries may have a practical outcome is in removing the soluble compounds of nitrogen present in sewage. Under the existing sludge processes very little of this soluble matter is recovered. It has been shown that if liquid sewage is used to ferment straw, the effluent is practically free from nitrogen; it has all been retained by the straw.

Enough has, perhaps, been said to indicate the great practical importance of the discovery made by the Rothamsted workers. The scientific advance is not less notable, and marks another stage in the capture by the biologists of the agricultural field of research.

Corrosion of Boiler Supporting Columns.*

SULPHUR IN ASH AND SOOT EATS AWAY MAIN COLUMNS SUPPORTING BOILERS.

A vital enemy of iron or steel is sulphuric acid. If the sulphur in the coal could be eliminated it would save us quite a few of our boiler troubles. Engineers are aware of this undesirable element getting into the tubes or drums of their boilers, and much attention is given to eliminating it from their feed water by use of the various compounds and water treatment devices. Engineers also realize that when it comes to the time for them to clean and prepare their boilers for an internal inspection, the brickwork must be removed from around the blowdown pipe; if the engineer in charge does not issue these orders to the one cleaning the boiler, the inspector will remove them himself.

The inspector realizes the great danger in allowing the soot and ash to bank around boiler blowdown pipes. This soot contains a large amount of sulphur, and when it becomes damp or wet soaks through the brickwork, whereby the sulphur and the oxygen in the water set up a chemical action. This chemical action causes pitting or corrosion which will in time eat through the metal if allowed to remain, and when the boiler is blown down may crack or explode, thereby blowing the fire into the fire-room, possibly injuring several persons. Such accidents are frequent. Lists of accidents are published periodically by insurance companies or by the department of labor at Washington. Boiler blow-

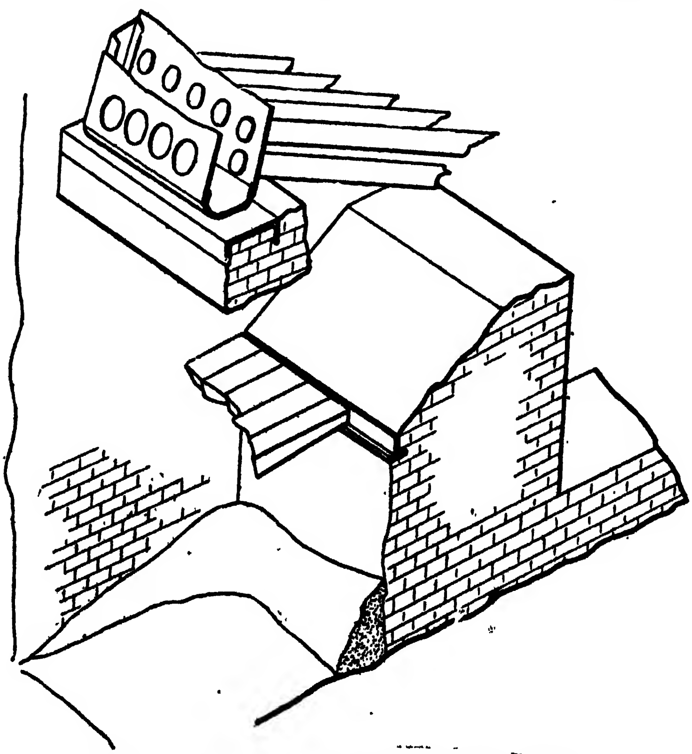


Fig. 1. Typical ashpit of water-tube boiler.

* From Power Plant Engineering.

pipes usually must be replaced about every five years, and accidents resulting from them usually cause considerable delay and expense.

How many engineers ever examine the foundations of their boilers or the columns which support the entire mass of weight? The owner would certainly object if you were to tell him that it would be necessary to remove a part of the brickwork at the base of the sidewalls of his boilers, especially where the boilers are in batteries.

Here is a vital consideration that should be called to the attention of all boiler inspectors and engineers, and it is something that we cannot lay too much stress upon. In visits to power plants, trouble resulting from corrosion at the foundation of main boiler supporting columns is frequently found. On one visit it was found that these columns that had been supporting a 1000-horsepower water-tube boiler had become so corroded at the base that it was amazing how it had stood. The brickwork or sidewalls evidently had been supporting the boiler against collapsing. After this discovery, the brickwork was removed from around all of the boilers in three large power plants operated by the company and five similar boilers were found in like condition, which had to be replaced at great expense and inconvenience.

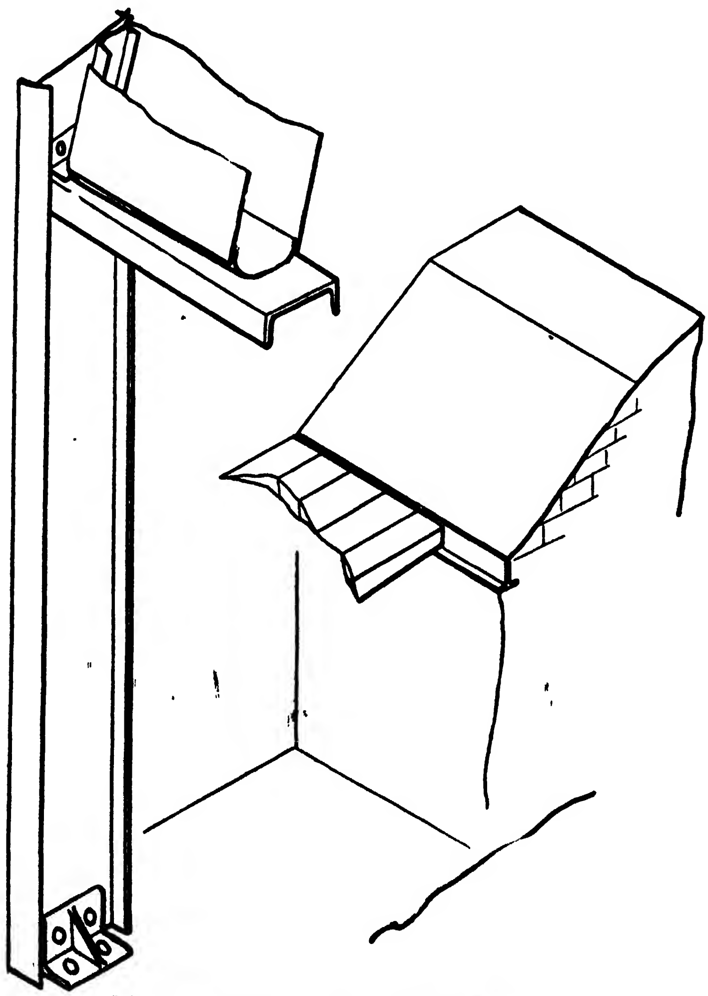


Fig. 2. Ashpit with brickwork removed.

Upon examination of these columns it was found that the ash and soot that had piled up along the sidewalls, and the water resulting from the quenching of the hot coals had penetrated the brickwork, and the sulphur in the refuse with the oxygen in the water quickly consumed the steel, causing this serious damage.

Figure 1 shows a typical ashpit of a water-tube boiler with the steel column hidden. Engineers seldom if ever stop to think that anything would ever happen

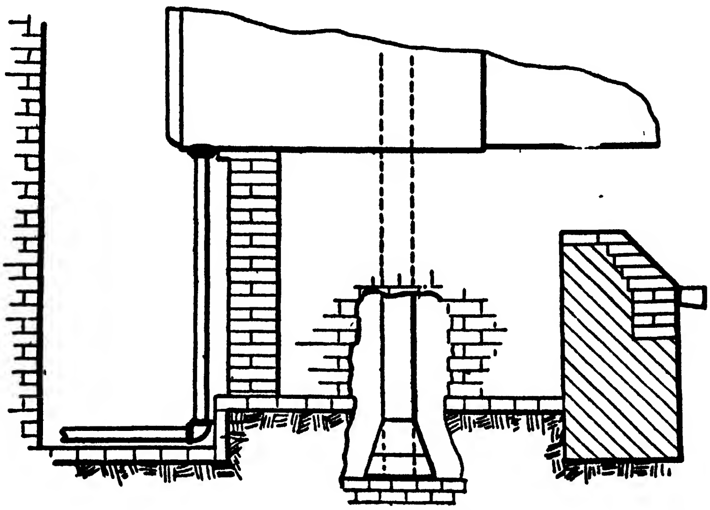


Fig. 3. Location of columns supporting return tubular boiler.

to them, as, to the eye, they look pretty well protected. But engineers must realize that this protection is only a porous fireproof brick which will absorb moisture readily. This moisture must pass through the ash or soot.

Coal from some mines will run about 4½% sulphur, and when referred to sulphur in the ash this figure is considerably higher. So it may be well under-

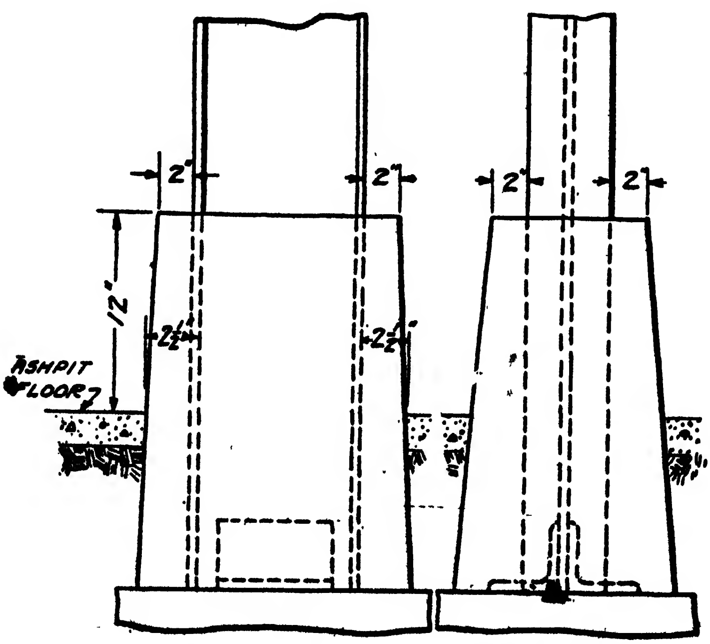


Fig. 4. Concrete casing to protect base of column.

stood that this moisture passing through the ash will absorb much of this sulphur, and if allowed to remain on the steel will cause rapid corrosion.

Figure 2 shows the same ashpit of a water-tube boiler with the brickwork removed. In this view, see how the main columns are located at the side of the ashpit. In Figure 3 is shown how the column is located on a horizontal return tubular boiler with the brickwork removed from around the base. This brickwork should be removed for a periodic examination.

This corrosion can be prevented by building a foundation of a good cement around the base which will extend about one foot above the ashpit floor, the proportions for which are shown in Figure 4.

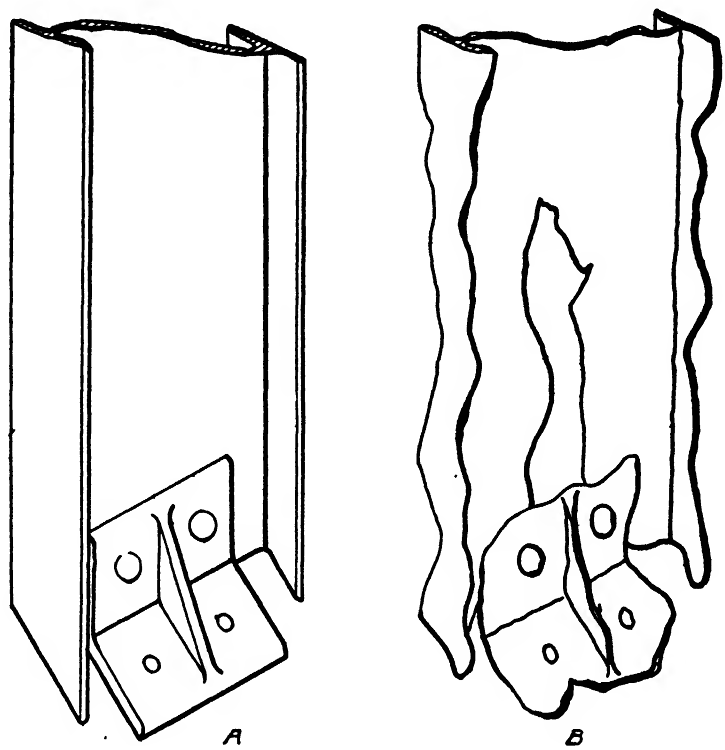


Fig. 5. Foot of column before and after corrosion.

In Figure 5A is shown an enlarged view of the columns that had to be replaced in the aforesaid plant, and 5B shows how they had been corroded away when discovered; the metal had been so eaten away that there was practically no support whatsoever. If engineers would examine their boiler foundations, not less than 25 per cent would find just such conditions.

Cleaning up a boiler-room is a man's job. Keeping it clean is a bigger man's job. Increasing its efficiency is a still bigger man's job—and this leads directly to a still bigger job. Why not start?

[W. E. S.]

The Effect of Some Decolorizing Carbons Upon the Color and Colloids of Cane Juice.*

By Joseph F. Brewster and William G. Raines, Jr.

This paper was presented before the Section of Sugar Chemistry and Technology at the 61st meeting of the American Chemical Society, Rochester, N. Y., April 26 to 29, 1921.

The matter described in this paper is the result of cooperation between the Bureau of Chemistry, United States Department of Agriculture, and the Louisiana Sugar Experiment Station. The work was done at the Station's sugar house and laboratory at New Orleans during the cane grinding season of 1920-21. The authors desire to express their appreciation and thanks to W. G. Taggart, assistant director of the Station, who, by helpful suggestions and actual labor, enabled them to obtain the results described herein.

Previous investigations at the Louisiana Sugar Experiment Station, the results of which have been published chiefly by Zerban and his co-workers, have demonstrated that filtration of cane juice with the aid of kieselguhr, followed by filtration with active decolorizing carbon, is greatly superior to the older sulfur-lime method of clarification in removing color and other impurities from the juice. The kieselguhr-carbon filtration process was given a trial on a large scale in Louisiana during the past grinding season, and reports indicate that it cannot yet be regarded as a commercial success, although sugar and molasses of excellent quality were produced directly from juice. The chief factor to be considered in explaining why the new process may not yet be successful is the cost of filtering materials, and probably also the costs involved in working the process, as compared with the cheap materials and the low costs of operating the older processes. The chief use of highly activated decolorizing carbons in the sugar industry will probably be confined for the present to the refining of raws.

In view of the above facts, and in consideration of the huge quantities of waste vegetable materials available for the manufacture of decolorizing carbons, it is natural that much interest has been created in the manufacture and uses of such carbons, and we think the belief is justified that high-grade carbons at low cost will be produced in the near future. The subject of the preparation of vegetable decolorizing carbons from various raw materials has been treated in the Louisiana Sugar Station's bulletin 167 (May, 1919) by Zerban, Freeland and Sullivant.

Up to the present very few decolorizing carbons are being produced on a large scale. Several carbons are being developed in this country, however, and at the suggestion of Mr. Paine of the Carbohydrates Laboratory, Bureau of

* From Journal of Industrial and Engineering Chemistry, Vol. 13, p. 921.

Chemistry, it was decided to test as many of these as possible at the Station's sugar house. Four such carbons were obtained.[1]

Theoretical Considerations.

Schneller[2] demonstrated the presence of polyphenols in various parts of the sugar cane by means of the well-known color reaction which these give with salts of iron. He concluded that the polyphenols, expressed with the juice and coming in contact with iron already present in the cane or dissolved from rolls, piping, and other sugar-house equipment, cause discoloration of the juice. Schneller also pointed out that the polyphenol-iron compounds are only temporarily bleached by sulfur dioxide and reappear on neutralizing.

Zerban[3] has studied some of the coloring matters of cane and has found that, in the methods of clarification generally practiced in Louisiana, the dark color in cane products appears to be due almost entirely to polyphenol derivatives occurring in cane juices, the color being two to three times as dark when ferric salts are present with the polyphenols. He also points out that under certain conditions the natural coloring matters of cane, anthocyanin and saccharetin, which are polyphenol derivatives, may contribute materially to the color of the juice.

It was found by Zerban and Freeland[4] that decolorizing carbons will remove practically all the color from cane juice, as well as the polyphenols, the iron combined with them, and substances which under certain conditions are capable of producing polyphenols.

In connection with the purification of cane juice there must be taken into consideration the presence of other impurities aside from those which are responsible for color; namely, impurities which exist in the colloidal state. Schneller,[5] and later Zerban,[6] called attention to this subject, and the latter, with others, is of the opinion that cane-juice clarification, whether accomplished by so-called chemical means or by the use of adsorbents, such as kieselguhr and carbon, is to be regarded as a colloid-chemical proposition.

The impurities of cane juice from the rolls may be considered to exist in all degrees of dispersion. The gross impurities, such as soil particles, finely-ground bagasse, etc., are visible to the eye. Some of these may be thrown down by centrifuging, but the liquid will still be opaque. If the centrifuged juice be poured upon a paper filter, some of the suspended matter will first pass through. As the pores of the paper become clogged the liquid will pass through clear, but by this time filtration will have become very slow. If, however, the raw juice

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[1] We owe our thanks to the National Carbon Co., of Cleveland, and to Dr. J. W. Turrentine, Bureau of Soils, U. S. Department of Agriculture, in charge of the potash plant of the Department at Summerland, Cal., for supplying us with 100-pound lots of their carbons.

[2] Louisiana Bulletin 157 (August, 1916).

[3] Journal of Industrial and Engineering Chemistry, Vol. 12, p. 744.

[4] Louisiana Bulletin 165 (March, 1919).

[5] Louisiana Planter, Vol. 56, p. 44.

[6] Louisiana Bulletin 173 (March, 1920).

is brought to boiling with about 2 per cent of its weight of kieselguhr, filtration is rapid, and the filtrate is brilliant and clear, although colored. If juice thus clarified be completely dialyzed and the dialysate evaporated to dryness, there will be found a solid residue which sometimes has a gelatinous appearance and often is nearly colorless. This residue contains both organic and inorganic material, as is shown by ashing. In dialyzing cane juice it has been noticed that a great deal of the coloring matter will pass through a collodion membrane, some of the color being adsorbed in the membrane itself.

Paine and Walton[7] made use of the dialysis method in comparing the efficiency of different kinds of kieselguhr, and it is at their suggestion that this method has been used for a part of the work reported here.

The colloids of cane juice have proved an abomination to the sugar manufacturer. They are thought to cause frothing during evaporation, and then often flocculate and precipitate in the syrup. They retard crystallization, and adhere to the sugar after it has been centrifuged, acting as a binder for coloring matter and forming a film on the sugar crystal which retains moisture, thus offering a favorable medium for the growth of molds and bacteria which brings about decomposition of the sucrose when the sugar is stored. To the syrup maker, on the other hand, the colloids may be regarded as being useful, in that they retard crystallization.

Sugar House and Laboratory Results.

Sulfur-Lime Process.—For the sake of comparison with the kieselguhr-carbon process by the dialysis method, three runs by the sulfur-lime process are recorded. These runs were made in the usual way, on about 3000 pounds of juice each, by sulfuring to 5 cc. acidity and liming back to 0.5 cc. Samples of raw, sulfured, and limed juice, respectively, were dialyzed. Each 200 cc. sample of juice, after mixing with a little toluene, was poured into a collodion sack of about 1000 cc. capacity and dialyzed, first in running tap water, then in four daily changes of distilled water. After dialysis, the contents of the sack were transferred and evaporated to dryness on the water bath, heated at 110° for 15 hours, and weighed. This gave total nondialyzable solids. The residues were then washed and reweighed.

The results of this treatment are shown in Table 1, expressed as mg. of nondialyzable solids and ash per 100 cc. of juice. No corrections have been made for change in specific gravity, as this was found to have little effect upon the figures.

[7] Science, Vol. 53, p. 266.

TABLE 1.—SULFUR-LIME CLARIFICATION.

Run	Solids			Ash		
	Raw	Sulfured	Limed	Raw	Sulfured	Limed
1	366.6	50.1	38.7	11.5	13.3	13.4
2	483.8	44.8	52.3	22.8	15.0	17.2
3	407.1	70.3	51.1	40.4	28.1	21.7

The significant figures of Table 1 are those of the juice after liming, since the impurities remaining at this stage of the treatment are carried through the following steps of evaporation and boiling. In Runs 1 and 3 there is considerable reduction in the amount of colloids by liming, while in Run 2 there is an increase. This increase is probably due to over-liming, it being well known that a part of the precipitate brought down by sulfur dioxide may be redissolved on liming back. No color determinations were made in connection with the sulfur-lime runs.

It is interesting to compare the quantity of colloids remaining in the juice after sulfuring and liming, as shown in Table 1, with those of the kieselguhr-carbon treatment of Table 2.

Kieselguhr-Carbon Process.—The kieselguhr-carbon runs were made as follows: To each clarifier of raw mill juice (about 3000 pounds) were added 20 pounds (0.66 per cent) of kieselguhr. The juice was heated just to boiling and filter-pressed. On running clear, the juice was returned to the clarifier and to it were added 30 pounds (1 per cent ash-and-moisture-free basis) of decolorizing carbon. This mixture was again brought to boiling and filter-pressed.

Samples of the mixed raw mill juice and the juice after each treatment were used for the analytical determinations. For dialysis, 200 cc. samples were treated as described in the sulfur-lime process.

The results of dialysis are given in Table 2. The raw mill juice is designated by Raw, the kieselguhr-treated juice by Kieselguhr, and the carbon-treated juice by Carbon. The first column of figures shows colloidal solids remaining after each treatment, expressed in mg. per 100 cc. The second column gives the per cent colloids calculated on the amounts before and after treatment. The last column gives ash in mg. per 100 cc.

It will be noted by comparison with Table 1 that, in general, less colloids are found in the juice after kieselguhr treatment alone than after sulfuring and liming. It may be supposed that liming contributes to the total colloids in the latter process, the supposition being well borne out by comparing the figures for ash. It is also known that the colloids of cane juice are reversible to acids and alkalies.

* TABLES 2 AND 3.—KIESELGUHR-CARBON CLARIFICATION. COLLOIDS BY DIALYSIS AND DECOLORIZATION.

Run	Carbon Used	Treatment	Total Colloids		Ash, Mg. per 100 cc.	Color	
			Mg. per 100 cc.	Per Cent Remaining		Tl. Units / 3	Per Cent Remaining
		Raw	152.8	....	13.8	....	....
4	A	Kieselguhr	22.6	14.79	3.3	185.3	....
		Carbon	11.1	49.11	3.0	8.6	4.64
		Raw	129.9	....	18.5	....	....
5	B	Kieselguhr	31.8	24.50	3.2	192.5	....
		Carbon	11.4	35.85	3.7	13.7	7.12
		Raw	225.9	....	12.2	....	....
6	C	Kieselguhr	37.1	16.42	5.1	204.2	....
		Carbon	11.3	30.45	1.9	12.8	6.28
		Raw	182.1	....	14.7	....	....
7	D	Kieselguhr	33.3	18.28	4.9	174.8	....
		Carbon	23.4	70.27	3.9	17.8	10.23
		Raw	407.1	....	40.4	....	....
8	A	Kieselguhr	45.8	11.25	7.9	194.9	....
		Carbon	18.8	41.05	3.6	25.0	12.82
		Raw	327.2	....	56.1	....	....
9	B	Kieselguhr	42.6	13.02	5.2	126.4	....
		Carbon	31.9	74.64	3.4	22.3	17.63
		Raw	243.9	....	27.6	....	....
10	D	Kieselguhr	34.7	14.23	4.5	156.2	....
		Carbon	34.4	99.13	4.5	23.3	14.92

In Runs 4, 5, 6, and 7 of Table 2 the raw juice samples were centrifuged before dialysis in order to remove mud and some of the suspended matter. In Runs 8, 9, and 10 the raw juice samples were not centrifuged. A comparison of these two sets of figures furnishes an idea of the kind and amount of material removed by treatment with kieselguhr alone. There is a variation in the amounts of colloids left after kieselguhr treatment which is no doubt due to variations in the tightness of the rolls in grinding. Such variation may perhaps also be explained by changes in the condition of the cane, part of which had been exposed to several frosts.

Colorimetric Determinations.—Table 3 contains the results of colorimetric determinations. These were made with the Hess-Ives tintphotometer in the manner described by Meade and Harris,[8] the table worked out by them being used for translating scale readings of the instrument to units of color. The seventh column

* Condensed. For complete tables see original article.

[8] Journal of Industrial and Engineering Chemistry, Vol. 12, p. 686.

contains the total color units, divided by 3, and the last column shows the percentage of this total left in the juice after carbon treatment.

Two runs were made with each carbon, but through a mishap at the sugar house the second run with Carbon C was lost.

A variation in decolorization is particularly noticeable in Runs 4 and 8, in which Carbon A was used, and in Runs 5 and 9, where Carbon B was employed. In attempting to explain this we would point out that in the second runs with each of these carbons a greater amount of total colloids was present in the juice after kieselguhr treatment in each case, which no doubt interfered with adsorption of coloring matter.

It is probable that as the amount of total colloids increases, the decolorizing power of any carbon is diminished.

The molasses from the carbon runs contained material in suspension which settled out upon standing. A similar precipitate had been observed previously by Coates and Slater[9] in syrup from sulfur-lime treatment, We made a partial analysis of our precipitate from molasses after freeing it from soluble matter and found it to contain 75.93 per cent ash. The ash contained 52.22 per cent silicon dioxide, 15.61 per cent ferric oxide and alumina, and 10.23 per cent calcium oxide. Qualitative examination showed the presence also of phosphoric acid, magnesium oxide, and a considerable amount of copper. These findings are in qualitative agreement with those of Coates and Slater. We also obtained a strong reaction for manganese.

The proportion of carbon used in the above experiments, 1 per cent on the weight of juice, is perhaps the lowest that it is profitable to use in most cases.

Repeated Use of Carbon.

In first reducing the juice to syrup as practiced at most of the sugar houses, or in refining raws, the proportion of carbon used is about 5 per cent based on total solids, which is nearly the same as our 1 per cent on juice. In order to gain a knowledge of what might be expected from repeated use of any particular carbon we made the following simple laboratory experiments, since the limited amount of cane available would not permit such tests to be run at the sugar house. Two hundred cc. of juice, first clarified with kieselguhr, were treated with 2 g. of decolorizing carbon, heated to boiling, and filtered by suction. When sucked dry the carbon was transferred to a second 200 cc. of juice, and the heating and filtration were repeated. The second filtration was in each case very much slower than the first, and on the third treatment, filtration was very difficult in most cases. Color determinations were made on each filtrate and the color units found by the use of the table of Meade and Harris.

The results of these experiments are shown in Table 4. Very good decolorization was obtained by a second filtration with Carbon A, while with Carbons B, C, and D, little or no decolorization was obtained. By a third filtration, not only was filtration very slow, but coloring matter was actually washed out of Carbons B and D. It was practically impossible to filter Carbon C on third treatment. It would seem to be unprofitable to use less of the three latter carbons

[9] Journal of Industrial and Engineering Chemistry, Vol. 8, p. 789.

for cane juice decolorization than in the above proportions, while with Carbon A fair results might be expected with half this quantity.

* TABLE 4.—REPEATED FILTRATION WITH SAME CARBON—COLOR REMAINING AFTER FILTRATION.

	Total Color Units Divided by 3			
	Carbon A	Carbon B	Carbon C	Carbon D
Before carbon filtration....	112.0	112.0	112.0	112.0
After 1st filtration	51.5	73.0	68.6	71.1
After 2nd filtration	78.5	104.8	110.0	115.9
After 3rd filtration	114.4	117.5	....	141.4

SUMMARY.

1. Sugar-house and laboratory tests were made on four decolorizing carbons.
2. Tables are given which show the amounts of solids and ash left after sulfur-lime and kieselguhr-carbon treatments. In general, fewer colloids were found after the use of kieselguhr alone than after the sulfur-lime treatment.
3. Colorimetric determinations were made on the juice treated with the four different carbons.
4. Tests were also made of repeated use of the carbons. In the case of one carbon only, was good decolorization obtained on a second filtration.

* Condensed. For complete table see original article.

[W. R. M.]

Report of Committee on Mill Equipment.*

By W. v. H. Duker.

Mill Equipment.

The price of a product is determined by the law of supply and demand.

With an oversupply of the product, in the manufacture of which we are interested, and no immediate prospect of an increased demand, the price is bound to be low for some time to come.

During such times everyone who has the interest of the sugar business in these Islands at heart needs to do his utmost to assist in maintaining it as a dividend-paying industry.

We might therefore begin by asking the question: "Do we, or do we not, put the sugar in the bags in the most economical way?"

But as the answer to this question would require much more information than we may hope to supply with our limited knowledge of the industry as a whole, we are forced to confine ourselves and limit the investigation to "Do we operate our mill equipment economically, and do we judge rightly about our methods of operating?"

For years past we have been looked upon as leaders in the sugar industry on account of the marvelous results obtained in our milling plants. Our rise to the top has been very rapid, and therefore it is possible that we did not get quite as firm a hold of the underlying principles as others who advanced at a little slower rate.

In Hawaii, we have always had peculiar conditions, due to climate, labor, position in the world, etc. This has been the cause of our having developed methods of our own, in field work, dealings with labor, factory operation, selling our product, and even in our chemical control.

It is, therefore, only a natural consequence that from all over the world men come to study our ways.

Their first impressions are generally very favorable, our climate appeals to them, and they are delighted with the way in which they are received with true American hospitality. And thus they express themselves as highly pleased, and make us believe that we are far ahead of all others and that we have little to learn as producers of sugar.

However, after our visitor sails away, and has time to think over what he has seen and heard, he often changes his first impressions; but of that we hear little or nothing.

Therefore, instead of giving a review of our mill equipment you will find in the following pages a criticism of experienced Java engineers on the use we make of it, and finally some opinions of our own men who have handled this machinery for the last ten or twenty years.

I have had the good fortune to come in contact with a few of our recent visitors, and, besides, I have studied articles written by some of them after their

* Presented at the Nineteenth Annual Meeting of the Hawaiian Chemists' Association.

return home; and as I have often heard it said that the object of these meetings is to encourage discussion on subjects of interest to the operating staff of the sugar mills, I would like to begin by relating a little experience I had not so long ago.

After taking a Java engineer around to several mills on Hawaii, and knowing that he had visited practically every mill on the other Islands, I asked him to give us his frank opinion and impression of our mill equipment and of our methods of operating it.

His answer was, "that he was much impressed, very much impressed indeed, especially with the willingness of the owners to spend money on equipment," and he added that "if you do recover the extra sugar (due to high extraction) it must cost you a lot of money to get it."

We can, of course, ignore this statement and say: "How dare he make such an assumption? We, with our high extraction, and the people of Java with their old-fashioned mills."

But undoubtedly there are others who question if we obtain our much-advertised milling results in an economical way, and it surely will do us no harm if we listen to what they have to say. Besides they are discussing our methods among themselves and have no particular interest in our affairs.

In a separate report,* therefore, are two translated articles, one by Mr. F. W. Bolk, of the Java Experiment Station (who needs little introduction after his personal visit in 1910, and the publication of a volumnious report on the sugar industry in Hawaii), and another by Mr. L. W. Hofland (the original of which appears in the Java Archief, No. 24, of June, 1920).

In both these articles our equipment is admired and envied, but our methods of operating, as well as our methods of control, are severely ciriticized.

When studying these articles we notice first of all that both in Java and in Hawaii the term "extraction" has been the cause of much misunderstanding. We realize, of course, the fallacy of this figure as a factor for comparison; in fact, this term has caused us a terrible lot of trouble, so much so, that several engineers have lost their positions on account of it; others have actually destroyed machinery in their futile attempt to reach the impossible. Now we cannot say that we did not know, because Dr. R. S. Norris, formerly of the Experiment Station staff, told us long ago, when he introduced the factors for milling loss and extraction ratio to be used instead, and Mr. Horace Johnson explained it in a lecture held for plantation men in October, 1919, and published in the H. P. Record of January, 1920.

"Of course, a 'high extraction' means much to the plantation if only we realize that the head luna has as much to do with it as the boy who carries the samples, but never should this term be used to judge the capability of the engineer in charge, or the efficiency of the equipment."

Therefore in this study of our milling efficiency we may well begin to note what Mr. Bolk remarked in 1910. He wrote thus:

"The higher extraction figures (considered apart from the actual better mill work on Hawaii) are partly due to:

(a) The relation of the juice purities in connection with the Brix of the first mill juice.

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* *Report of the Committee on Manufacture of Sugar and Utilization of By-products*—**Hawaiian Sugar Planters' Association, 1921.**

(b) Probably too low a figure for fiber.
(c) The fact that Hawaiian cane holds less water per 100 fiber. Moisture contents in bagasse from 40 to 42% in cane with equal fiber content are constant exceptions with us."

And if this be true, let us watch out and not measure our efficiency as sugar manufacturers by the sucrose extraction alone.

We may follow with what Mr. Horace Johnson refers to in his report on sugar manufacture to the Hawaiian Sugar Planters' Association in 1918 and published on page 252 of the proceedings. He says there: "We would call your attention to another source of loss due to fermentation, viz., that due to dirty conditions around the mill. This loss does not appear in our undetermined quantity, nor is it taken into account by our methods of control. That it should be seriously considered will be seen from the following extract from a report of the work done in the Java mills which carry on a much more complete control of the mill work than we do:

" 'It has been observed that the mill control, as required by the Java Experiment Station, was much too troublesome for practical use, and that considerable simplification might be considered. The result of recent deliberations was, however, that the figures required were really necessary to obtain a good insight into milling work, and that it was obligatory to collect these data in order to serve as a basis for improvement as soon as a falling-off in the efficiency of the mills was noticed.

" 'An example of the excellent results of careful mill control is given by the fact that large losses of sugar, which until recently escaped detection, are now brought to light by the close control. It was originally the custom to ascertain the amount of sugar in the juice and in the bagasse, and to consider the amount of sugar in the cane to be the sum of the two, making no allowance for unaccountable losses during milling. The new control records the amount and the sugar content of the different mill juices separately, and that of the total of the mixed juice; and it found in many instances that the amount of sugar in the mixed juice was smaller than that of the sum of the component parts. This strange phenomenon could not be ascribed to a personal error, as the weighings and determinations were all made on the same scales, with the same instruments, and by the same individuals, and yet it always tended in the same direction.

" 'It was found that in the tanks, gutters, collectors, etc., of the juices, especially those of the maceration with the last mill juice, such huge amounts of bacteria, yeasts and fungi could accumulate that large quantities of sugar, amounting to as much as 6% of the total quantities, were lost by inversion.

" 'The new control can detect these losses, which may be rather easily overcome by continually cleaning the conduit through which the juices pass, or even by using double sets of tanks, suction pipes, collectors, stone-catches, etc., of which one set is cleaned and disinfected while the other one is working. This rather simple device has already reduced these unaccountable losses in many factories to an insignificant fraction of their former sum, thereby proving that they had really existed, and were not a consequence of errors.' "

We had more of such warnings when at last year's meeting before the Sugar Planters, Mr. J. N. S. Williams read a report on a milling problem (page 32, proceedings) which we probably would call a control problem, but it is a serious charge against our official methods of control. We simply say, the sucrose in the mixed juice plus what we have found in the bagasse constitutes the sucrose in the cane, and if there are any additional losses in the mills we do not recognize

them. But from the above we see that we can no longer afford not to recognize these losses, for it may mean the difference between working at a profit or at a loss; and it appears to me that this loss is large enough to neutralize any advantage gained by the extra extraction obtained through the introduction of the Messchaert grooves, and that we are wasting the royalty money.

Again, we cannot excuse ourselves by saying that we did not know; we have had warnings enough, even if it had only been the songs of the "Piffle Mill Staff" relating to the ever-increasing stream of "cush-cush" coming down the rollers and souring our mills.

Referring further to the annual synopsis of Mill Data for Java of 1919, and in connection with the losses mentioned above and the loopholes in our methods of control, may I submit the following comparison:

DIFFERENCE IN PURITIES BETWEEN FIRST MILL JUICE AND MIXED JUICE — HAWAII SYNOPSIS, 1920.

	First Mill Juice Purity	Mixed Juice Purity	Difference
Puunene	88.91	85.90	3.01
Oahu	87.2	82.84	4.36
Ewa	83.1	79.19	3.91
Maui Agr.	90.11	86.67	3.44
Pioneer	88.98	85.86	3.12
Hilo Sugar Co.	87.41	85.18	2.23
Onomea	88.6	85.2	3.4
Olaa	86.9	83.1	3.8
Hawaiian Sugar Co.	88.67	85.66	3.01
Hakalau	88.6	85.0	3.6
Wailuku	89.22	85.05	4.17
Waiakea	87.10	83.88	3.22
Honokaa	87.36	82.81	4.55
Pepeekeo	87.68	83.42	4.26
Paauhau	88.1	82.7	5.4
Honomu	88.6	85.0	3.6
Average	87.91	84.22	3.69
JAVA SYNOPSIS, 1919 *All installations of Crusher and 12 R. M.*			
Bangsol	84.9	83.3	1.6
Brangkal	83.9	82.4	1.5
Djati Carang	81.1	78.9	2.2
Djati Carang	82.1	79.4	2.7
Djatiwangi	83.7	81.1	2.6
Kentjong	82.4	79.7	2.7
Meritjan	83.0	80.6	2.4
Selovedjo	86.8	84.8	2.0
Tanjoenan	86.6	84.5	2.1
Average	84.2	82.2	2.0

The true average difference for 24 Java mills equipped with crusher and nine-roller mills is 1.9.

The placing of the sugar in the bags is directly in proportion to the purity

of the juice, and therefore these figures are important and show clearly that it is high time to tear ourselves loose from the term "extraction," and talk more about recovery—that is, the percentage of the sugar delivered in the bags.

Part of these differences is due to losses by fermentation, and in several factories they have succeeded already in reducing this loss materially. But part of this drop in purity may be due to qualities of the cane or the leaves, sampling of the juices or methods of analysis.

There are several matters not removed from the cane by pressure, and not considered as belonging to the juice, which are removed when subjecting this cane to extraction with water.

Referring to the above paragraph, it is not unlikely that a part of this large difference is due to our method of milling—that is, to the large dilution. From Bolk we have the following:

"When bagasse is subjected to a high pressure in a hydraulic press and not extracted, then, after the first drop in purity, juice is recovered from the bagasse with an equal or *higher* purity as the pressure increases." That was found to be the case on Hawaii, and I have on record the results of different tests which I have discussed in another chapter.

With a purity of last juice of 83.8 in a test without maceration, the residual juice as determined with a Soxhlett apparatus was 67.9; another test gave 85.7 and 69.6. But here in Hawaii, too, many have recognized that the juice must be removed by pressure and the sucrose must not be obtained by washing it out. Mr. John Greive, engineer for the Hilo Sugar Co., gives this view, in an article written by him and appearing on page 56 of the H. P. Record of August, 1920, when he writes: "The fundamental principle of milling is the extraction of the juice from the cane by means of pressure, and, in the opinion of the writer, the point of primary importance in high class mill work is the proper and effective application of that pressure."

Bolk writes on this:

"The results of the mutual control (weekly comparative mill data of Hawaii) show clearly that there is no reason to expect results from a much higher maceration, and the most contradictory figures may be grouped together. Personally I am convinced that many factories macerate too high. It looks to me that even on Hawaii, for crusher and four mills, they do not need to go beyond 30%, and only then when the water is divided over the second and third mills. With three mills a maceration of 20% should be sufficient in general. That higher maceration can be applied, for more mills, is self evident, provided the water quantity is spread over more mills. Nearly all factories practice return juice maceration, and I am sorry to admit that in Java, with our different work in the first part of the mill train, it would not always prove to be an advantage; for Hawaii, with the better preparatory work, I believe it is. Yet I do not consider it of any definite advantage to carry this so far, and to apply for four mills the theoretical rational system, as do a few factories on Hawaii, behind the first mill the juice from the third mill, behind the second mill the juice of the fourth mill, behind the third mill water. For excessive high maceration, behind the third mill in one dose, there may be a good reason. This diluted juice is practically a mixture of juice and water, and thus the excess of water which never did anything in the fourth mill may then be used in the third mill. But I would think that, when the same quantity was divided, two-fifths behind the second mill and three-fifths behind the third mill, and only the diluted juice of the fourth

mill would be returned behind the first mill, better results would be obtained. In fact now and then they seem to forget that returning diluted juices is contrary to the first principle of sugar making—removing the juice from the mill as "quickly as possible in order to lime and heat it."

And thus the further we go into the subject the more we see that it is much more a question of operating than one of equipment, and to show that others in these Islands hold this view I refer to the statement made on page 240 of the proceedings of the Thirty-eighth Annual Meeting of the H. S. P. A.:

"These excellent results have not been obtained by the general installation ot new machinery, but by the more efficient operation of the old equipmnt."

In a report to the Planters in 1905, Mr. C. C. Kennedy gives a review of the history of the sugar industry in these Islands; he says: "As the sugar price of 8c a pound belonged to the past, and there was every indication of a further drop, it was clear that everything needful should be done to bring to market a larger part of the sugar originally present in the cane." And a little further: "A couple of seasons later the Honolulu Iron Works, under Mr. C. Hedemann, built such a mill (nine-roller mill with hydraulic pressure), and the first one was erected at Honomu in 1897. From then on a crusher and nine-roller mill was considered the standard equipment."

I especially draw attention to this statement because today there are a few mills with this very same simple equipment getting as high results as the best.

It appears to me, therefore, that there remains quite a bit to be learned in this sugar producing industry. and the sooner we all realize this the better for us; and whilst in the mood to receive instruction let us have in mind those wise words of the late Mr. Gartley: "If you want to make a success of business you must look around and study how your successful neighbor does it." And when the question comes down to the ways of handling the equipment we have at our disposal, can we also hold our own? By all means let us be open-minded and see then how others do it and what they say about our ways.

"*The Puunene Mill.*—The idea embodied in this construction is the result of remarks made while the mill was operating, and checks perfectly, as we will see later, with the Hawaiian method of milling. It had occurred to them that the top brasses would wear more on one side than on the other, because the pressure between back roller and top roller is greater than between feed roller and top roller. The resultant of both forces does not run in a vertical direction, in which direction the top roller *should* move against the hydraulic pressure, but in a slanting direction towards the front roller. It was then noticed that the top brasses tipped and were likely to become jammed in the cheeks, causing the hydraulic pressure to work irregularly and with shocks, because of not responding quickly enough. To meet this condition a mill was constructed whereby the top roller did *not* move vertically in the cheeks, but slanting in the direction of the resultant of both forces, or towards the feed roller.

It appears to me that they tried to correct a mistake originating in the idea in Hawaii that the front opening should be such as just to allow for a certain grinding capacity, and then to do all the pressing with the top and back roller, whereby the above mentioned conditions becomes much worse than it

ought to be. And it would be far better to construct the mills in a way whereby a position is obtained which allows the resultant of the forces to be as near vertical as possible. Because, if the top roller was exactly between the two lower rollers, then we could be sure that both rollers would do equally as much pressing, and the mills would work most economically and without chances of jamming the top brasses."

Now I know full well that in many of our mills we make the mistake referred to above, and I strongly recommend the study of the before mentioned articles, which explain in detail the following few points, most of which are admitted by our own practical mill engineers to be steps nearer to an economical operation of the milling equipment:

1. That better results are obtained and the machinery subjected to less wear when grinding a heavy blanket under a slow circumferential roller speed than a thin blanket under a high roller speed.

2. That the top roller brasses must lift perpendicularly in the housing without any tipping or side friction.

3. That the strain in the mill housing must be divided equally and symmetrically in the housing.

4. That reabsorption of juice can be decreased by opening of the back roller and that setting up of the back roller beyond a certain limit gives no better results. Or, if we prefer to take counsel from men who have worked in our midst, I may quote Noell Deerr, who found that:

"Juice extraction by single pressing up to a very high pressure is much inferior to juice extraction by repeated pressing under a much lower pressure." In other words, that grinding as we do by operating a two-roller mill in a three-roller mill housing is not an economical way of using the equipment.

Or the following statement by Mr. John Greive, page 66, H. P. Record, August, 1920:

"There is still some difference of opinion amongst engineers with regard to the speed at which mills should be run to do the best work. Some maintain that high surface speed of rollers with thin blanket is the correct method, while others agree with the writer, that, providing juice drainage is sufficient, just as good results can be obtained at the same tonnage ratio with low surface speed and correspondingly thicker blanket."

The answer to the first question, then: whether or not we use our equipment in an economical way, you will find best expressed in the contributions sent in by several mill engineers, copies of which are attached hereto.

The second question: whether we judge rightly on the method of operating with our present methods of control, I think needs to be answered in the negative, and I believe that a revision of our present official methods is sorely needed. We will then probably find that any improvement therein should not be confined to milling only.

The encouraging part in this criticism of our work is the realization that the steps which need to be taken are those which will help to increase the efficiency of the human element rather than that of the machinery, and where this

is in accordance with the conclusion arrived at by men in our community whose life work it is to help to improve the social condition, it is all the more gratifying that this comes up in a time when the industry is temporarily suffering under the stress of a low sugar price, which makes any installation of new equipment a real hardship, especially if we must admit that we do not yet know all about using the old equipment in the most economical way.

W. v. H. DUKER,
Chairman, Committee on Mill Equipment.

Comment by Mr. Herbert Walker: When our Javan friends have shown that they are able to get high extraction, we may believe they are keeping it low purposely. The remarks of Prinsen Geerligs on this subject are illuminating. (Int. Sugar Journal, June, 1920, p. 322, "The 1919 Java Sugar Crop.") "The moisture content of the bagasse is rather high . . . average 47.01 per cent . . . The sugar extraction in juice on 100 parts of sucrose in cane is also not particularly good, being 92 per cent; this gives rise to some disappointment because the arduous work done by the Technical Department of the Java Sugar Experiment Station in connection with the improvement of the milling plants had led us to believe that, especially in a year when small amounts of cane had to be worked up, a considerable rise of that value might be witnessed. The figure has been decreasing since 1917, and is not now much higher than in 1910, when it amounted to 91.2 per cent."

The following are the before-mentioned contributions and comments received from several of the local mill engineers and chemists:

From Mr. John S. K. Cushingham, Engineer Honokaa Sugar Co.

In answer to your letter of September 13th, referring to my results of the trial on the Java engineers' report on milling, I have the following to say: That we can do the same quality and quantity of work with our mills using less power.

After hearing the report from Java engineers and their method of reasoning on cane milling, I decided that I could give their ideas a trial with but few changes. The top caps had already been adjusted sufficiently to allow for the brasses to lift perfectly perpendicular, which made the resultant of the forces lifting the top roller, running perfectly in the center of the mill housing. The engine speed was reduced, and to mill the same amount of cane a thicker blanket was put through. The mill openings were not increased, but four accumulator plates were removed, which lessened the hydraulic pressure by 36.8 tons, to allow for the thicker blanket.

Resulting from the trial, I found that much engine and mill friction has been eliminated. Now I am making more trash and having better results in the fire room.

Heretofore there was more exhaust steam than could be used; now, with the slow engine speeds, I find that we can forget about the exhaust we had to blow off to the atmosphere.

Messchaert grooves are very essential with this slower mill speed and thick blanket to allow for the draining of the juice.

The boiler pressure runs from 85 to 90 pounds pressure. The crusher gear-

ing pedestals broke from an accident a few months ago, and I am handicapped by not having the use of the crusher. All the crusher can do now, until we install the new one, is to level the feed. Without the crusher working we have a twelve-roller mill.

Following is the data for weekly averages for three weeks before and after the test:

Week Ending	R. P. M. Main Engine	Weights per Lineal Foot	Tons Cane per Hour	Bagasse		Milling Loss	Extra Ratio	Dil.
				Sucrose	Moisture			
Aug. 6 ...	76	72	37.85	1.49	41.49	2.64	.24	35.3
Aug. 13 ...	76	72	37.07	1.57	41.86	2.81	.28	33.2
Aug. 20 ...	80	72	36.86	1.89	42.47	2.41	.25	33.1
Sept. 3 ...	64	66	38.00	1.41	41.96	2.51	.25	32.1
Sept. 10 ...	65	65	37.59	1.42	42.02	2.54	.25	34.7
Sept. 17 ...	66	65	37.47	1.34	41.51	2.37	.24	32.9

From Mr. J. W. Kennedy, Engineer Pepeekeo Sugar Company:

In answer to your request I will try to give you a description of our mill equipment at Pepeekeo.

The weight carried on hydraulics is 380 tons. Pressure on rollers per lineal foot, 76 tons. Speed of rollers in feet per minute: First mill, 17.927; second mill, 19.671; third mill, 21.580. Revolutions of engine per minute, 50. Tons fiber per lineal foot per hour, .581 ton. The latter figure was obtained by taking the tons cane per hour to date this season, the average for the season being 23 tons per hour.

I have always made it a practice to keep my mill in first-class condition. In the off season I look after everything that may give bother during the grinding season, and so obviate stoppages during the progress of the crop. Our stoppages last season from breakdowns only amounted to 45 minutes, and this was caused by an occasional chain link or carrier slat breaking, and sometimes a piece of iron in the mill.

To obtain the best results in extraction, I find that it is best to stand around and observe things, and so increase the opportunities for improving conditions. The rollers and juice grooves are also kept in good condition. For the past six years the extraction has been slightly raised annually — 96.89, 96.97, 97.05, 97.50, 97.97, and 98.13 — but in order that good results may be obtained in extraction it is necessary that grinding should be uninterrupted.

I do not offset the hydraulic jacks and have no tipping up of brasses. The top roller is kept so steady while in operation that the only way in which any motion in the brasses may be detected is by placing one's finger on them. You probably have placed a bar of half and half solder in the middle of the bagasse blanket and caught it as it came out on top of the bagasse roller and examined its thickness. In the last mill here it comes out 3/32" thick. Before passing this piece of solder through we stop the mill as it stands, clean away the bagasse

blanket for about a foot and place the bar of solder at the entrance of top and feed rollers.

I find better results from using hot maceration water. We take the water from the last effect of the evaporators and feed by a steam nozzle at the entrance to the Ramsay scraper. The water is heated to 202° Fahr. Some engineers object to this system, claiming that it makes the mill slip or causes roller shells to shift. I have had no trouble from either, but I do find that it helps in extraction.

The first factor in a mill, however, is to have the men trained to carry out the orders as given to them. Our mill and boiling house have been painted throughout at considerable cost for paint, but it makes the place look good and every man seems to take an interest in keeping things clean. Each man has his instructions to see that his department has been properly cleaned before turning it over to the man on the next shift.

From Mr. E. K. Horkes, Engineer Waiakea Mill Company:

Am in receipt of your very interesting communication of July 22. In reply to your request regarding my opinion of our method of milling in Hawaii as compared with the method practiced in Java, have the following to say:

If we stop to consider that sugar mills are operated for the purpose of paying dividends to their stockholders, and that the manufacture of sugar is only a means of obtaining that end, we may look at the things in a different light.

Let us take first the method of milling practiced in Hawaii. Our bagasse rollers are invariably screwed as tightly as possible against our top rolls. This method, as we all know, is very destructive to the shells of both rollers, as well as brasses and roller pinions. While off-setting our jacks equalizes to some extent the pressure applied to the two bottom rolls, it does not equalize the friction between the two sides of the top brass and the mill housing. That enormous friction is present is evident from the fact that in the majority of mills obtaining a high percentage of the sucrose in the cane, scarcely a season passes without the breakage of some part of the mills, and a material decrease in the life of rollers, brasses, and pinions. While some of these breakages are due, no doubt, to the crystallizing of the metal, the majority of them are due, the writer believes, to overloading and jamming.

The method of compound maceration certainly aids in obtaining a high extraction with a minimum amount of water being used, starts fermentation in the raw juices with a material decrease in the purity of the mixed juice before it is limed and heated.

Let us take now the method of milling practiced in Java, where the openings between the feed and top rollers and bagasse and top rollers are almost equal. Undoubtedly there is a big decrease in the power required to operate these mills. With an opening between bagasse and top rollers a closer setting of the feed roller must be obtainable, resulting in a more equal distribution of the work done by the two bottom rollers. While the writer has no data at hand, the life of a roller shell or mill pinion must be many times that of one in Hawaii.

From Mr. William Wyllie, Engineer Onomea Sugar Company:

The milling equipment at Onomea consists of 14-roller train with shredder.

The mill might be termed as a heavy duty design, steel housings, steel top caps, steel side caps with rigid king bolts, roll shafts mostly carbon steel with increased journal diameters. Roll dimensions 32" x 66" medium and soft texture, juice grooves 3/16" wide, 1¾" deep, 2" pitch on feed rolls, 5/32" wide, 1¼" deep, 2" pitch on discharge rolls.

The past few years our extraction has increased year after year, irrespective of the quality of cane, there being quite a number of reasons for this: First, the boiling house, remodeled in 1914, new evaporators and pre-evaporators installed, which allowed an increase of maceration water from 20% to 40%. Second, new boilers, allowing an increase in steam working pressure to 125 pounds per square inch. Third, new mill steel housings and caps complete, rolls with small journal diameters discarded, replaced with new shafts of greater diameter. Fourth, cane shredder. Fifth, two-roll crusher ahead of shredder, dimensions 28½" diameter, 60" length, equipped with five juice grooves ½" x 2¾" x 12" pitch on bottom roll.

With a mill of the above type, how should an engineer proceed to obtain that confounded extraction? The only method to obtain this high extraction is close mill settings, and speed up for the desired tonnage of cane; say 30 lineal feet per minute surface speed of rolls, with hydraulic load of 80 tons per lineal foot width of roll, should be about normal running. We all know what bagasse is, but did we ever consider its high elasticity as regards to milling? For instance, our shredded cane entering first mill will average about fifteen inches in depth of blanket feeding into small opening. There must be some reason for this, which is absolutely on account of the elasticity of the material. This being true, it is then demonstrated that bagasse is highly elastic and can be fed to mills with close settings. In theory, as well as in practice, take a layer of bagasse of a certain thickness under pressure and another layer of bagasse of greater thickness under the same roll pressure, will the mean pressure to which the whole of the bagasse is subjected be the same in the two instances? The answer is no, for the simple reason bagasse is highly elastic and there is sufficient resistance in a layer of it to diminish considerably the pressure in the center of the blanket. It follows, therefore, that any feed of crushed cane, or shredded cane, giving a layer of bagasse beyond the thickness at which the difference in pressure may be disregarded necessarily leads to lower extraction.

Hence, a thin layer of blanket passing at high speed between the points of application of pressure of rolls is the correct method. The bagasse must give up what it is going to part with, no matter how short a time may be the contact as it passes between the rolls. This method is nothing new, but nevertheless correct.

There being no standardization of mill settings, this depends entirely on texture of rolls for feeding, also returner bar setting, and some cases high fiber in cane. Keep setting as close as possible just to choking point with the desired tonnage of cane. The forward mills in some cases can be set closer than the following, so long as the mill feeds, close opening accordingly. Discharge rolls usually are set close, provided top and bottom rolls are of about the same diameters. Occasionally there is a danger of slippage should rolls be of hard texture; in this case setting up screws can be eased off a little to overcome this without materially lowering extraction.

The extraction we now have on record required heavy type mill housing, rolls of about equal diameters and properly tuned up, equipped with crusher and shredder. Continuous operation of plant, which is very important, with blanket of bagasse about the same thickness throughout the whole train. Hot macerating water not less than 40%; juice grooves kept clean, which requires two to three sets of scrapers per roll. Observe that hydraulics are working freely and mill moaning a little; be sure it's on the job; also observe that rolls don't get out of linement by bearings wearing or heating, it being absolutely essential to keep rolls level to relieve excess friction.

Juice grooves in bottom roll of Krajewski crusher have been quite an improvement, the idea being to prevent juice from squirting, but it was also observed an improvement in feeding and a decided gain in extraction.

The question of an economical extraction could be answered in a hundred different ways, and is a delicate subject to touch on, it being entirely up to the proper party responsible for the maintenance of the plant. The engineer's object in mind must be to obtain the highest possible extraction with the existing equipment. Onomea is entirely self-supporting on bagasse fuel, no waste molasses or any other substitutes used, and operating under these conditions spells economy.

From Mr. Y. M. Jaouën, Engineer Laupahoehoe Sugar Company:

Referring to the part in your letter where you say that you have felt doubtful whether the extra sugar extracted does land in the bags, I have for some time felt that way myself. All mills have been crazy after extraction, regardless of anything else. I cannot account for the purity of the mixed juice being lower at the present time than it was a few years back. However, in our particular case, it may be the large amount of dilution we are using this year. We try as much as possible to keep our mill beds clean, by steaming out all around every morning and evening, when grinding night and day, and every noontime while grinding day only. The only effective way to remove the slime around the mills and juice strainers and troughs is to use boiling water under good pressure, but it is impossible to keep pumping water in the juice in order to wash away the slime, so we do the best we can with steam. This keeping the mills clean is a problem to overcome, which is bothering quite a number of engineers.

Regarding the use of the second pressing water for maceration, I have for a long time been against its use. I believe whatever sugar there is in it is sour before it reaches the mill, and therefore does more harm than good.

I note your questions regarding the mill openings. I believe in keeping the feed roll as close up as possible as long as it will feed, the closer the better, but there is a point where we cannot go further, as we have to put through so much cane per hour. The best result, of course, is obtained by slow grinding, but in our case we are expected to put through the mill all they can supply us, so having only a certain size mill, we have to run accordingly. The best result is obtained with a mill of this size by grinding 24 to 25 tons per hour, and we have often done 30 tons day after day. In our mill, under present conditions, with only 80 pounds of steam on the engines, we have to drive the mills beyond the speed they ought to run; otherwise the engines would stall twenty times a day. As it is, we are forcing our Corliss; one revolution it cuts off, the next it takes steam full

stroke, thereby jarring the whole engine. By closing the feed and backing off the discharge roller the difference in power owing to the change would not be noticeable.

I am satisfied we haven't sufficient power on our mills, owing to the reason given above.

Through several tests, made by cutting down the maceration, we have always found that the extraction went down. What the result would be if we had the power to turn our mills, and with less maceration, I cannot say. But it is my intention, when we have the new boilers set up, to make tests and find out just how we can obtain the best result.

I quite believe the oftener the blanket is brought under repeated pressure the better, but I also believe that it requires more than a nine-roll mill. With a twelve-roll mill the mill extracts the juice that we have to do with water in a nine-roll mill.

From Mr. F. Foster Hadfield, Chemist Hilo Sugar Company:

The following figures show the relation between delays and sucrose recovery:

	1921		
	Second Period	Third Period	Fourth Period
Total recovery	91.846	92.158	91.236
Total time lost by delays ...	54 hrs. 50 min.	25 hrs.	82 hrs. 45 min.

From Mr. Eliot, Chemist Paauhau Sugar Plantation Company:

The following data all have more or less bearing on theories discussed in this report:

PAAUHAU SUGAR PLANTATION COMPANY

Nine-roller Mill

Crop	Crusher juice	Mixed juice	Decrease in purity	Syrup	Increase in purity	Last mill juice	Diff. btwn. crusher and last mill juice	Extraction	Dilution
1908	88.15	86.37	1.78	89.13	2.76	79.38	8.77	92.69	16.39
1909	90.91	87.60	3.31	90.36	2.76	80.70	10.21	92.71	17.27
1910	89.18	86.26	2.92	89.54	3.28	81.94	7.24	91.06	15.19
1911	90.33	87.66	2.67	89.58	1.92	80.48	9.85	91.45	9.76
1912	89.51	86.87	2.64	88.82	1.95	79.10	10.41	92.35	19.56
1913	90.29	86.50	3.79	87.97	1.47	78.12	12.17	92.98	40.10
Average	89.73	86.88	2.85	89.23	2.35	79.95	9.78	92.21	19.71

Twelve-roller Mill.

1914	88.93	83.67	5.26	86.67	3.00	68.75	20.18	96.27	36.30
1915	89.62	84.76	4.86	87.13	2.37	68.45	21.17	96.88	32.78
1916	88.59	84.96	3.63	86.52	1.56	67.78	20.81	97.61	39.00
1917	90.33	86.13	4.20	88.06	1.93	68.92	21.41	98.05	42.27
1918	87.51	82.17	5.34	84.50	2.33	65.66	21.85	96.79	28.81
1919	88.26	83.46	4.80	85.15	1.69	71.36	16.90	97.43	36.30
1920	88.10	82.70	5.40	84.80	2.10	69.60	18.50	97.53	40.28
Average	88.76	83.98	4.78	86.12	2.14	68.65	20.11	97.22	36.53

HAWAIIAN FACTORIES' ANNUAL SYNOPSIS—SUMMARY

Crop	Crusher juice	Mixed juice	Decrease in purity	Syrup	Increase in purity	Last mill juice	Diff. btwn. crusher and last mill juice	Extraction	Dilution
9-roller Mill 1910	88.86	86.25	2.61	88.44	2.19	79.25	9.61	92.91	25.91
9-roller Mill 1920	86.98	83.58	3.40	84.91	1.33	70.96	16.02	95.82	39.07
Increase or decr'e.	.....	.....	.79	.....	.86	.....	6.41	2.91	13.16
12-roller Mill 1910	90.20	87.21	2.99	88.61	1.40	78.30	11.90	93.82	29.11
12-roller Mill 1920	87.20	83.42	3.78	84.55	1.13	68.74	18.46	97.53	38.40
Increase or decr'e.	.....	.....	.79	.....	.27	.....	6.56	3.71	9.29
15-roller Mill 1910	88.89	84.76	4.13	86.20	1.44	73.3	15.59	95.53	39.50
15-roller Mill 1920	88.73	85.81	2.92	86.57	.76	70.58	18.15	97.56	24.53
18-roller Mill 1920	83.14	79.19	3.95	81.15	1.96	64.88	18.26	97.08	39.15
21-roller Mill 1920	90.11	86.67	3.44	88.40	1.73	67.24	22.87	99.05	54.32

N. B.—In 1910 there was one and in 1920 two 15-roller mills. There were no 18 and 21-roller mills in 1910; only one of each in 1920.

All averages are arithmetical.

HAWAIIAN FACTORIES' ANNUAL SYNOPSIS.

Comparing the purities of the crusher juice against the purity of the syrup, we have the following:

	Crusher Juice Purity	Syrup Purity	Difference
9-roller Mill 1910	88.86	88.44	.42
9-roller Mill 1920	86.98	84.91	2.07
12-roller Mill 1910	90.20	88.61	1.59
12-roller Mill 1920	87.20	84.55	2.65

Why not use the apparent purity of the crusher juice in the S. J. M. formula for calculating the recovery? Allowing a difference of, say, .8 between the purities, it seems reasonable to assume that the rest is lost between the crusher and the evaporator. Probably more at the mill than from the juice scale to the evaporator.

By increasing the purity of the mixed juice 1% there is a calculated increase in recovery of .83% and 1.19% on the polarization in mixed juice. No doubt about it that this is a very serious loss that has been overlooked for years.

COMPARISON OF ACTUAL WEIGHT OF CANE AND CALCULATED WITH DIFFERENT NORMAL JUICE FACTORS

(From Paauhau Lab. Report 32, March 8th, 1921.)

Actual weight of cane, 699.85 tons.

Calculated weights:

Factor used	95	96	97	98	99	100	101
Tons cane	706.35	698.75	691.43	684.25	677.38	670.22	663.12

From Mr. T. V. Petersen, Chemist at Laupahoehoe Sugar Company:

The following figures relate to a test on deterioration of so-called sweet water from second presses, which is often used for macerating purposes:

	Brix	Polarization	Purity
Standing half hour	2.0	1.4	70.0
Standing one hour	2.1	1.3	61.9
Standing one and a half hours	2.1	1.2	57.1
Standing two hours	2.2	1.2	54.5

From Mr. W. K. Orth, Superintendent Koloa Sugar Company:

In answer to your letter of June 17th, in regard to mill equipment, I have this to say for Koloa:

The extraction figures for last season and this season up to date (29 weeks in both cases) are:

	1920	1921
Extraction % Pol. i. c.	96.69	97.73
Maximum for one week	97.08	97.78
Milling loss	3.02	2.31
Minimum for one week	2.71	1.78

Extraction and milling loss are appreciably better this year, even if we give due credit to the lower grinding rate this year of 29.12 tons cane per hour, against 32.21 last year. Dilution was alike 44.00%.

The improvement is due to several changes in the mill. First, to a new crusher with hydraulics in place of springs, original size as previous.

Then we replaced four rather worn rollers in such manner that the little-

worn back rollers of each mill were placed in front and the new rollers became bagasse rollers, the old front rollers going in reserve. This combination works well as long as the top rollers are the smallest in the set and the bagasse rollers the largest. The juice grooves were deepened to 1½" and the rollers set as close as possible. The distance returner bar to back roller was increased from ¼" to ⅜" and ½".

Another slight improvement worth mentioning is a piece of 00 centrifugal screen put on the mill juice screen frame where the juice spout enters the screen trough. This fine screen retains quite a bit of fine cush-cush that was formerly pressed through the larger openings of the old screen by the fall of the juice onto the screen.

Much of the better recovery here is, I think, only apparent, Howe juice scales furnishing better means of control than the unreliable Automatic it replaced.

The improvement in waste molasses gravity purity is rather slight and, I believe, partly due to the increased pan, crystallizer, and centrifugal capacity on account of the slower grinding. I did record an average of 37.6 so far this year, but have done almost as well, or poorly, before. The averages for the last five years, counting back from 1920 as first year, are: 38.0, 38.7, 38.4, 38.6, 39.2.

I compiled molasses figures of four representative mills, one on each Island, and find the averages for the last six years, beginning with 1915 as first year:

	1915	1916	1917	1918	1919	1920
Gravity purity	40.09	40.51	40.76	39.29	37.35	37.72
% Sucrose lost in Mol. % S. i. C.	6.51	7.46	7.06	7.21	6.47	6.67
Purity first expressed juice	88.4	88.3	87.9	88.5	88.4	88.5

Not much of an improvement. This year apparently some better results will be shown, again due, in part at least, to the reasons I gave for Koloa, the temporary larger capacities in T. C. H.

Still, in spite of this reasoning, which at that is in particular supported by the good results at Pioneer Mill since their new centrifugals are in operation, I am not yet convinced that additional outlay for equipment and labor to reduce losses in waste molasses might not be spent to more advantage at the clarification stations than at pan floor, crystallizers, and centrifugals. As long, I mean, as cash allowances will be as limited as they threaten to be for the next few years. Of all the many suggestions that come to mind, I like to mention the use of Filter-Cel. I am just now experimenting with it in a small way, with the object to avoid liming, or rather over-liming, the mud juice. The results are very promising, but can unluckily not be brought to anything like conclusive facts when saving and "let George do the experimenting that costs money" is the parole.

N. B.—I notice that there has been so far almost every week a decrease in purity from mixed juice to syrup, or at most a very slight increase, in three mills that I know have the H. C. & S. continuous settlers—in Puunene, Lihue, and

Makee. It would be interesting to find out if there is perhaps an imperfect movement of the juice in some parts of these settlers that gives rise to inversion.

I am sorry, but that is all I have to offer this year.

Mr. H. S. Walker, superintendent with Pioneer Mill Company, contributes the following:

In reply to your letter requesting information as to the improvements put in here during the last few years and their effect on extraction and recovery, I submit the following:

PIONEER MILL — IMPROVEMENTS SINCE 1912.

1913.

Changed from 9 to 12 r. m.
New steel mill building and electric crane over mill.

1914.

Ramsay scrapers installed.
March 9, 1914—Messchaert grooves put in feed rollers of second, third, and fourth mills.
Sand filters replaced by wire cloth.

1915.

Replaced intermediate bagasse carriers on all mills by Ramsay macerating conveyors.
Messchaert grooved back roller of fourth mill.
Put in one set of 9 knives, 6" apart, 3" from carrier.

1916.

Messchaert grooved remaining front and back rollers.
Williams shredder installed.
Motorized drives of Lillies, unloader, knives, shredder, and centrifugals.
Six 7x20 R. T. boilers (replacement).
One calandria pan of 900 cu. ft., in July.
One settling tank of 1100 cu. ft.
Four mud presses of 800 sq. ft. each.
Six 40" centrifugals.

1917.

One 800 K.W. turbo generator.

1918.

Number of knives increased to 13.
Capacity of calandria pan increased to 1100 cu. ft.
Two 360 h.p. Badenhausen boilers for running the turbine.
Six 700 cu. ft. crystallizers.
Two mud presses of 800 sq. ft. each.

1919.

None.

1920.

Crusher, 34" x 72", with engine.
One three-roller mill, 34" x 72".
Searby shredder, 72".
New cane carrier, 72".
Number of knives increased to 27.

1921.

Standard evaporator, 24,000 sq. ft. h. s., replacing two Lillies of 16,840 sq. ft. h. s.
One settling tank of 1100 cu. ft.
Sixteen 40" centrifugals for low grades.

Replying to your question as to whether increased extraction has been due to skill of operating or to the newly installed machinery, I think that most of the improvement in extraction at Pioneer in the last ten years has resulted directly from additions or improvements to the mill. Our extraction with a 9-roller mill in 1905 was reported as 94.93. Seven years later it was only 94.87. Following the change to a 12-roller mill for the 1913 crop, extraction went up to 96.13. Messchaert grooves, put in gradually during 1914 and 1915, had very little influence on the extraction, as it was only 96.32 in 1915. The effect of the grooves seems to have been to allow about 20% more cane to be ground than formerly without a loss in extraction. The shredder was used during only part of 1916. The combined influence of Messchaert grooves and shredder increased the extraction a little over 1% from 1913 to 1917. During the next two years no changes were made in the mill and there was very little gain in extraction. The change to a 15-roller mill in 1920, with a wider crusher and better shredder, resulted in a gain of 0.67 in extraction at a 9% faster grinding speed. With the same equipment in 1921 extraction fell back 0.27, though the average tons cane per hour was a little more. Nineteen twenty-one was an exceptionally bad year, both for milling and boiling house work, owing to the prolonged grinding season and the considerable amount of dried-up cane ground.

Judging from our total recovery from year to year, it might be argued that we have spent a lot of money and have nothing to show for it. The overall recovery in 1921 was lower than in any year since 1912, in spite of a higher extraction, and it is quite true that we have been getting less "sugar in the bags" of recent years. A calculation of possible recovery by the s. j. m. formula, however, shows that, considering the lower syrup purities, the boiling house work has at least not fallen off in recent years, and it seems reasonable to believe that, given the same cane to start with, the total recovery would have increased in proportion with the increased extraction. I doubt if this can ever be proven by comparing the work of different years, on account of the variation in the cane itself and the lack of absolute accuracy in methods of chemical control. It would be very difficult, if not impossible, for instance, to prove the simple statement that 1001 tons of cane yield more "sugar in the bags" than 1000 tons.

There are three possible arguments that we are getting little or no benefit from the extra four or five per cent extraction we have obtained in the last ten years or so.

(1) It is believed by some that larger "unknown" losses of sucrose take place at the mills and that long trains of mills, heavy crushing, and fine shredding may increase these losses, even though their "extraction," figured from the sucrose left in the bagasse, may be reported higher. The only way such losses at the mills could be caused is by the action of some living organism—oxidation by the atmosphere is out of the question, as sucrose solutions are not affected by atmospheric oxygen. Repeated experiments made at Pioneer last year showed that the deterioration of our mixed juice on standing one hour without any preservative was so small as to be almost within the limit of experimental error, and that the loss of sucrose during a liberal allowance of fifteen minutes to get from

MILL AND BOILING HOUSE DATA — PIONEER MILL COMPANY.

	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Tons cane per hour	42.04	46.08	53.75	55.98	56.47	58.95	57.10	56.29	61.40	62.77
Dilution	51.05	35.49	26.54	34.19	42.38	38.47	33.45	36.34	31.96	39.53
Extraction	94.87	96.13	96.20	96.32	96.72	97.25	97.22	97.45	98.12	97.85
Recovery % polarization of cane	86.56	88.38	89.27	90.32	89.64	89.93	89.18	89.77	89.58	87.34
Composition of "1st mill juice"	Cr. & Cr. & I M	Ir.	Ir.	Cr. & Ir.	Cr. & Cr. & Ir.	Cr.	Cr.	Cr.	Cr.	Cr.
Purity crusher or 1st mill juice	89.46	88.89	88.50	90.09	88.73	90.32	88.93	88.76	88.98	87.01
Syrup	88.69	88.96	87.27	87.47	86.41	88.25	86.20	85.85	86.26	84.28
Drop in purity	0.77	-0.07	1.23	2.62	2.32	2.07	2.73	2.91	2.72	2.73
Last mill	78.20	73.58	73.91	74.16	70.29	72.47	73.02	67.54	65.71	60.91
% recoverable sucrose in last mill juice	85%	80%	80%	80%	76%	79%	79%	73%	70%	63%
Recovery % polarization mixed juice	91.23	91.94	92.79	93.77	92.68	92.48	91.73	92.12	91.30	89.27
Tons molasses	5858	5185	5228	5462	6612	6037	6625	5937	6230	8084
								37.5*		
Gravity purity waste molasses	45.82	42.32	39.71	37.64	38.43	39.08	38.39	38.00	37.91	36.98
Unknown losses	1.10	1.30	0.71	0.73	0.52	1.37	0.81	1.37	1.66	1.38
Theoretical yield, 86 j. 97 s.	88.55	90.10	91.14	91.90	91.62	91.38	91.63	91.77	91.80	92.11
Java ratio	82.6	84.5	84.0	83.2	81.5	82.0	81.3	81.6	81.0	80.6
Quality ratio	6.93	7.06	7.31	7.05	7.43	7.07	7.48	7.12	6.96	7.13
Tons cane per ton sugar	7.15	6.82	7.16	6.84	7.35	7.06	7.52	7.09	7.03	7.40

* By dry lead method.

the mills to the heaters could not have averaged more than 0.03% at the most, of the total sucrose in juice.

Mr. J. N. S. Williams, in a contribution to the Committee on Manufacture of Sugar and Utilization of By-products, quoted from the reports of two factories:

Plantation A: Extraction, 89.1%; fiber, 13.3%.
First Mill Juice, 16.6 polarization; 88.3 purity.
Calculated normal juice, 16.1 polarization; 86.5 purity.
Pure sugar in cane, *279.4 pounds* per ton.

Plantation B: Extraction, 96.34%; fiber, 13.76%.
First mill juice, 17.50 polarization; 87.55 purity.
Calculated normal juice, 15.55 polarization; 83.05 purity.
Pure sugar in cane, *268.21 pounds* per ton.

He concludes that Plantation B, having apparently a better cane than A to start with, judging from the first mill juices, must have destroyed sugar in the milling process because it is charged up with less total sucrose in the cane.

This reasoning would be perfectly logical if all factories at all times ground a cane of absolutely uniform composition, and if the pressure on all "first mills" were so regulated that the composition of the "first mill juice" bore a constant relationship to the per cent sucrose and purity of the cane itself. Unfortunately this is not the case. Analysis of the juice that happens to be expressed by the first of a train of mills may, by the use of a factor derived from past records of the same kind of cane in the same factory, give a fairly close approximation of the total sucrose actually in the cane, but as a means of anything but very rough comparison between factories it is not very reliable. In fact, by a judicious selection of figures almost any argument might be proved from the variation in this factor $\frac{\text{Polarization of cane} \times 100}{\text{Polarization 1st mill juice}}$ or so-called "Java Ratio." The ratio for Plantation A was 84.2, while that for B was 76.6. If we found that all factories getting low extraction had high Java ratios, and those getting high extractions had low Java ratios, the deterioration theory might have some weight, but according to the 1920 annual synopsis it is just as easy to prove that sucrose is destroyed by not squeezing the cane hard enough. Union Mill, with an extraction of 90.29, has a Java ratio of only 75.8, while Olowalu has an extraction of 98.06 and a Java ratio of 81.0. Puunene, with an extraction of 98.92, has a Java ratio of 83.1.

The average extraction of all Hawaiian mills in 1920 was 97.45. To see if there was any tendency for mills getting high extraction to have low Java ratios I divided the mills into two groups, those above and those below 97.45 extractions, and averaged them separately:

	Over 97.45	Under 97.45
Number of mills	16	25
Extraction	98.10	95.50
Java ratio	81.62	79.98
First mill juice, polarization	17.00	16.24
First mill juice, purity	87.97	86.59
Syrup purity	85.86	84.05
Drop in purity	2.11	2.54
Polarization % cane	13.65	12.97

The mills getting the higher extraction *happen* to have a *higher* Java ratio and *less* drop in purity from first mill juice to syrup. To my mind the only thing this proves is the uselessness of trying to gain any information from such comparisons.

Actually of two mills grinding exactly the same cane, the one getting the lower extraction would be charged up with slightly more sucrose in the cane if the calculation were made by the "inferential" method illustrated in our "Methods of Chemical Control." In calculating the purity of the "normal juice," the juice left in the bagasse is assumed to be of the same purity as the last mill juice, whereas it is generally found that each successive portion of juice extracted has a lower purity. The error is not great, and tends to disappear with higher extractions.

2. In order to get the last portions of sugar out of the cane it has to be so thoroughly broken up, macerated, and heavily crushed that a great many more impurities enter the mixed juice than do when a lower extraction is obtained. Undoubtedly at some time before 100% extraction is reached the impurities extracted with the last portion of sucrose will be in such large proportion that this last juice will be worthless to the boiling house even if obtained at no extra expense. Some consider that we may have already reached this limit at around 97.5 extraction. Attempts to prove or disprove this by comparisons of the drop in purity between "First Mill" juice and mixed juice or syrup are of little value on account of the great variation in the composition of the cane itself. This was especially noticeable at Pioneer this year. Our smallest weekly average drop from crusher juice to syrup purity was 1.31, with a last mill juice purity of 61.42 and an extraction of 98.02; the largest drop was 5.50, with a last mill juice purity of 55.96 and an extraction of 97.76.

Another source of error in comparing present work with earlier years is the lack of knowing just what we are comparing. According to our official methods "*First Mill Juice* is that issuing from the crusher and the first mill." Since the advent of the shredder a number of factories are returning maceration in front of the first mill and must perforce get their so-called first mill juice sample from the crusher juice alone, which may be a point higher in purity than the combined crusher and first mill juices.

Still another chance to go wrong in comparisons comes from the introduction of variety canes. Previous to 1915 this plantation had only Lahaina cane. In

1921 only 40% Lahaina cane was ground, the balance being made up of Striped Mexican, D 1135 and H 109.

In my opinion the purity of the last mill juice (from both rolls) is the only even approximate check we have on the gain due to increased extraction. In a 12-roller mill about the last 2% and in a 15-roller mill the last 1% of sucrose extraction is due to the last mill. The percentage of sucrose available in these last increments of extraction can be calculated from the s j m formula. I think the arbitrary standard suggested by Mr. S. S. Peck several years ago, that the economic limit of extraction was reached when the last mill juice purity dropped to about the purity of our low-grade massecuites, is as good a guide as we now have. This means that about half of the last 1% of sucrose extracted would be available, the balance going into the molasses.

I am inclined to believe, subject to correction, that with four- or five-cent sugar we are just about at the economic limit with 98 extraction, and that another one per cent will hardly pay for the extra expense in fuel oil, broken rollers and boiling-house equipment required to maintain it.

3. According to the s j m formula, if the last 1% of sucrose is extracted at 55 gravity purity a little over half of it is recoverable when making sugar of 97 purity and waste molasses of 37.5 purity. The s j m formula, however, while mathematically correct, does not take into account qualitative differences in the impurities which may make it easier or harder to work the molasses down to a given purity, and it may be possible that the impurities brought into the juice with the last few per cent of sucrose are of such a character that the molasses due to the last mill juice cannot be exhausted to 37.5 or even 47.5 gravity purity with the methods now used. This point has been touched on in the past, but has never had the attention it deserved. As an extreme instance of what *might* be happening, suppose our last mill juice impurities were similar to those in beet molasses. Beet factories, working their low grades in about the same way we do, are unable to exhaust their final molasses to much less than 55 gravity purity. It is evident that a last mill juice of the composition of diluted beet molasses, although of 55 purity, would yield us no sucrose at all and would be worse than useless to the boiling-house. The s j m formula would still hold good, but we would have to substitute 55 for m as well as for j in the case of such a last mill juice.

I hope this supposition is not correct, but so far we have little proof one way or the other. If there is anything in Geerligs' glucose-ash ratio theory, last mill juice should be much more difficult to crystallize down to a molasses of our ordinary purity than is the first mill juice, as there is a decided tendency for the glucose-ash ratio to decrease in the last portions of juice extracted. Data on this subject is not very abundant. Geerligs cites a few analyses of juices from different mills which illustrate this tendency, but the extraction is so low they are not of much use to us. Mr. Glick ran one test this year on Crusher, Mixed and Last Mill juice from the same cane:

	Crusher	Mixed	Last Mill
Brix	22.95	15.40	1.50
Apparent purity	82.05	77.58	69.3
Gravity purity	82.57	77.66	66.0
Glucose	1.590	1.240	0.1
Ash	0.631	0.545	0.087
Glucose-Ash	2.521	2.304	1.153

Unfortunately this was deteriorated cane with a very high glucose content to start with, but the tendency to a diminishing glucose-ash ratio is very evident.

Mr. Peck at the 1918 meeting of the H. S. P. A. suggested that it would be of value to carry on experiments under the auspices of the Station to determine whether we are actually getting sugar from the increased juice that we are extracting, intimating that the small increase in total recovery we are getting might be due to improved methods in the boiling-house *in spite of* a higher extraction of impurities and sucrose at the mills, and agreeing with Dr. Norris that the only way to prove it would be to find out by experiment what purity molasses could be gotten from the last extracted juice.

To carry out such an experiment properly would be more than one factory could well undertake, as it would require special apparatus for clarifying and boiling last mill juice separately, also probably a small crystallizer and centrifugal machine. The whole thing could be done for probably less than five thousand dollars. If it should happen that our last mill juices cannot crystallize out sucrose to yield anywhere near as low a purity waste molasses as we think, it might save us hundreds of thousands of dollars to know it, even at this late day.

Until some such experiment has demonstrated the possible recovery from last mill juice, it seems to me that we shall have to reply to the question, "How much of this increased extraction are you getting in the bags?" by saying frankly, "I don't know."

In discussing mill and boiling house improvements we are apt to consider only the question of increased extraction and greater recovery of sugar, neglecting an equally important point, the value of increased capacity. Practically all the additions to our milling equipment, such as Messchaert grooves, shredders, increased number of rolls, have a double advantage. They can be used either to increase extraction at the same grinding speed or to increase capacity without sacrificing extraction. In our own case the gain from being able to grind faster has probably been worth fully as much if not more than that from increased extraction. In 1921, for instance, our average tonnage per hour was nearly 50% greater than in 1912. This speed did not happen to be necessary in 1921 owing to the shortage of field labor, but was of considerable value in lessening the extra fuel consumption which is ordinarily caused by an irregular cane supply. In 1920 the value of being able to grind faster was especially pronounced. The 1920 crop was finished in 161 days grinding, just two months less time than was needed in 1912. By finishing up in June we were able to get nearly all our sugar to market before the big drop in price came.

Two months delay in marketing 5000 tons of sugar would have cost us

probably as much or more money than we have ever spent in all our mill improvements. Another big advantage of reserve capacity was in being able to speed up the crop and get finished while the juice purities were still good. Most of us have realized this year the loss from deteriorated cane during a grinding season unduly prolonged by causes which unfortunately could not be remedied by mill equipment.

Summary.

Since 1912 we have expanded from a 9-roller to a 15-roller mill, put in Messchaert grooves, a shredder and a larger crusher, and have increased the boiling house to correspond with the larger mill capacity. The extraction has increased 3 points; the waste molasses purity has dropped from 45.82 to 36.98. In spite of this our overall recovery in 1921 was only 0.78% more than in 1912, and less than in any other year since then. This is explained by the lower syrup purities in recent years. Calculation by the s j m formula shows that, given the same purity of syrup each year, there would have been a progressive increase in overall recovery. The drop in syrup purity is not due to a greater loss of sucrose by deterioration at the mills, and is due only in part to an increased extraction of impurities. Attempts to calculate the latter by comparisons based on "first mill juice" are unreliable, owing to variations in cane, crushing and sampling. The purity of the last mill juice is a fair indication of the value of increased extraction and, as far as our present knowledge can be relied upon, we are getting out as sugar "in the bags" from fifty to seventy-five per cent of the last two or three per cent of sucrose extracted by the mills. It is barely possible that qualitative differences in the impurities last extracted may make the sucrose accompanying them much less valuable than we now believe. This point can and should be settled by experiment. Increased extraction is not the only advantage gained from mill improvements; capacity and flexibility may be of equal or greater value than extraction.

STEAM TRAPS: THEIR USE IN THE BOILING HOUSE.

By G. F. Murray, Sugar Boiler, Hamakua Mill Company.

The use of steam traps in the boiling house proper was not advocated by sugar boilers until comparatively recently, the general opinion being that in order to drain heating surfaces properly it was necessary to have steam blowing through to the hot well. In fact it is still common practice in some localities, especially with coil pans, to have the tail pipes fitted with "tell-tale" pipes to show the drainage, and in order to be sure the pan man will usually allow steam to blow through.

Traps in connections with heaters, pre-evaporators, or first bodies of evaporators are not necessary as long as the pressure used does not exceed 5 pounds, as with that pressure it is possible to submerge the outlets of the various drains in the hot well to prevent the loss of steam.

However, it is sometimes necessary, even ~~in the~~ best balanced factories, to use live steam, either as make up or to speed up the process, and if the various apparatus are not properly equipped a serious loss of steam results.

When installing traps, two things should be taken into consideration: First,

the capacity of the trap in gallons per minute; and, second, head room available below heating surface to be drained.

In considering the size of a trap to be used it is good practice to calculate the maximum gallons per minute of condensate the trap will be called upon to handle. For instance, a calandria pan will deliver more condensate the first hour of boiling a strike than any subsequent hour.

It is a good plan to have a trap of at least 10% oversize.

Traps should be set not less than six feet below the lowest part of the heating surface to be drained; in fact, the greater the fall between the heating surface and trap the less trouble will be encountered in its operation.

The traps should discharge into a pipe large enough to handle the water without any back pressure on the trap.

A sediment catcher should be installed on the inlet pipe to trap, and should be bled at intervals to prevent any particles of scale, etc., from finding their way into the valve mechanism and interfering with the proper functioning of the trap.

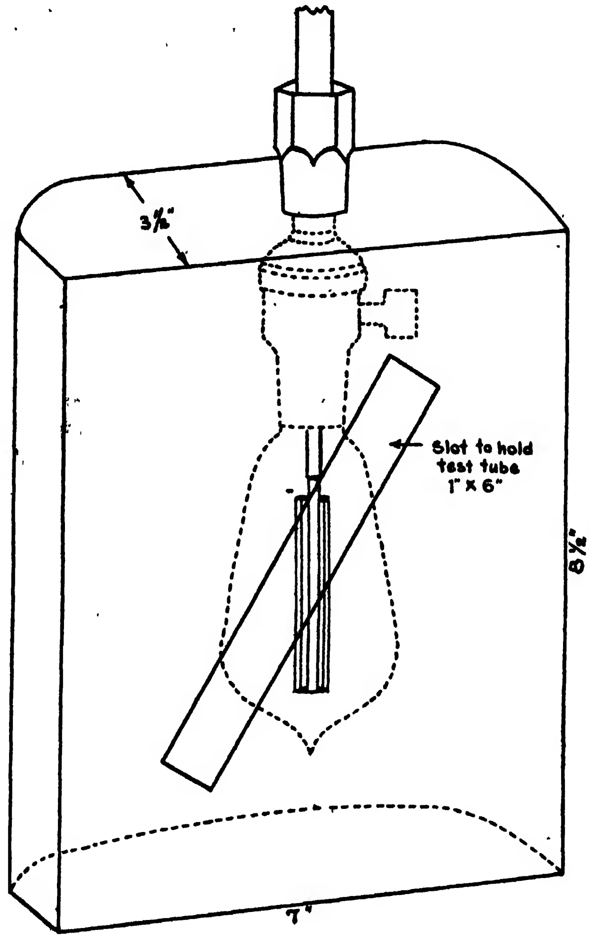
In some factories coil pans are fitted with a trap for each coil, but one trap of ample size will usually suffice if the tail pipes are fitted with proper check valves and discharge to a manifold before entering the trap. In connection with coil pans it has been found necessary to bleed the sediment trap once during each strike to remove any incondensible gases that may accumulate.

The type of trap to be selected is largely a matter of opinion. The writer prefers a trap with all working parts exposed, as it is possible to tell at a glance whether the trap is functioning properly or not.

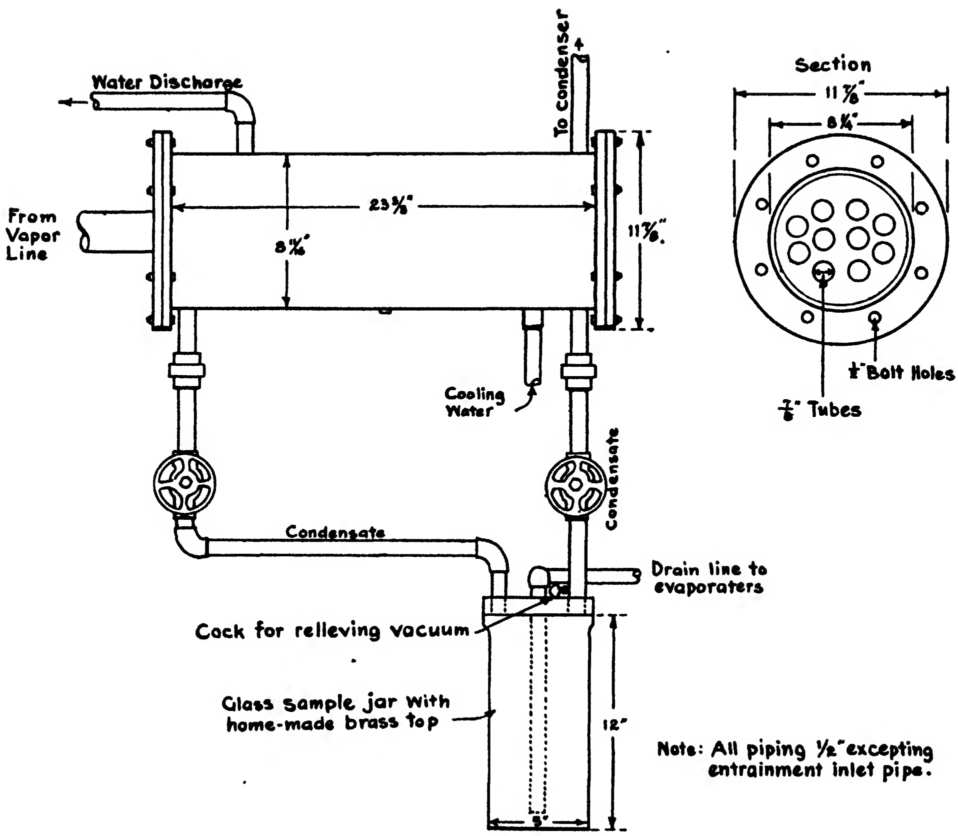
In conclusion, the advantages of steam traps in the boiling house are manifold. Their proper use means faster boiling, better drainage of heating surfaces, more condensate, less worry for the sugar boiler, less steam consumption, and, through the latter, more trash in the fire room.

Entrainment Indicator.

This is a device for testing the rate of settling in mixed juice after it has left the heaters, which consists of a box made of sheet brass 1/16″ in thickness, with a slot approximately 6″ long by 1″ wide, at an angle of 45°, and containing an electric globe.



A test tube, 6″ long by 1″ diameter, is filled with juice and placed in the slot and the action observed. The object of the slot at that angle is so that the suspended particles which have a certain amount of air adhering to them can rise to the top, where it is released, the particles flowing down the side to the bottom without obstructing the other particles. RAYMOND ELLIOTT.



Planned and installed by
Mr. Murray, Chief Engineer
at Paauhau.

Paauhau Plantation Co.
Entrainment-Indicator
June 8, 1921.

SUGAR PRICES FOR THE MONTH

Ended November 15, 1921.

		96° Centrifugals		Beets	
		Per Lb.	Per Ton.	Per. Lb.	Per Ton.
	(Oct. 16, 1921)......	4.11c	$ 82.20		
	" 18............	4.055	81.10	No quotation.	
	" 19............	4.00	80.00		
[1]	" 21............	4.155	83.10		
[2]	" 24............	4.00	80.00		
[3]	" 25............	4.11	82.20		
[4]	" 26............	4.08625	81.725		
	" 27............	4.11	82.20		
[5]	Nov. 2............	4.0626	81.25		
	" 4............	4.11	82.20		

[1] Cubas 4.11. Venezuelas 4.20. Export.
[2] Philippines.
[3] Cubas.
[4] Philippine and Porto Rico 4.0625. Cubas 4.11.
[5] Porto Ricos.